

# **Evaluation of National Air Quality Forecast Capability (NAM-CMAQ)**

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Sarah Lu, Ho-Chun Huang,  
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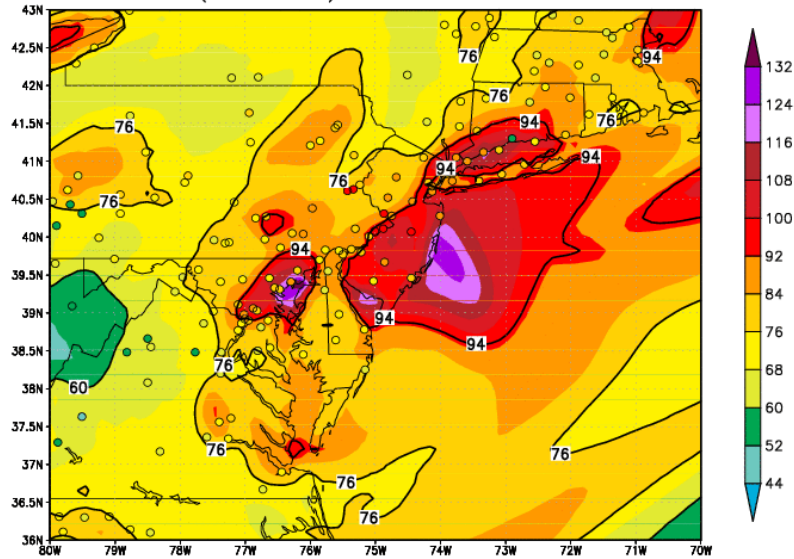
9/20/2010

# NCEP Major Tasks

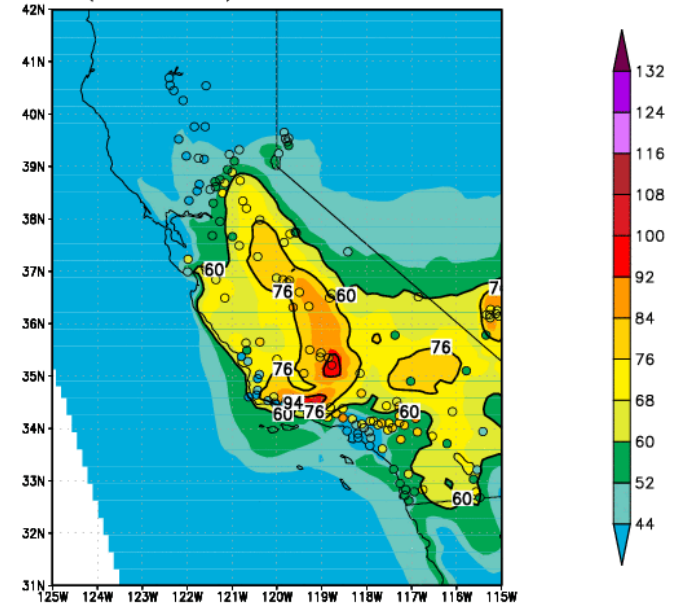
- Lead transition, testing, evaluation and **implementation** of upgrades
  - Jianping Huang, Youha Tang, Marina Tsidulko
  - NAM-CMAQ AQFC
  - NCEP Forecast Verification System
  - NEMS-NMMB/GFS Chem modules
- Perform and evaluate **retrospective testing** of NCEP NWP models
  - Marina Tsidulko
  - NAM, NMMB, 4 km
  - Potential upgrades to NCEP NWP models & impact on AQFC
  - Support AQF retrospective & rt runs
- **Improved met-chemistry coupling**
  - Youhua Tang, Jianping Huang
  - Provide and evaluate additional NAM fields
  - Inclusion of shallow convection, PBL fields
- **Develop Global aerosol capabilities** (off-line) within NCEP Global framework
  - Ho-Chun Huang, Sarah Lu, new hire
  - leverage JCSDA, NASA, OAR
- Develop, test and evaluate **coupling of global AQFC with regional AQFC**
  - Sarah Lu, Youhua Tang
- Develop **inline, interactive** regional and global chemistry within NEMS framework & GSI aerosol data assimilation- S. Lu, H. Huang
  - leverage JCSDA, NASA, OAR

# Spatial Verification Plots

Test2 (Combined) 8-hr max 01SEP2010

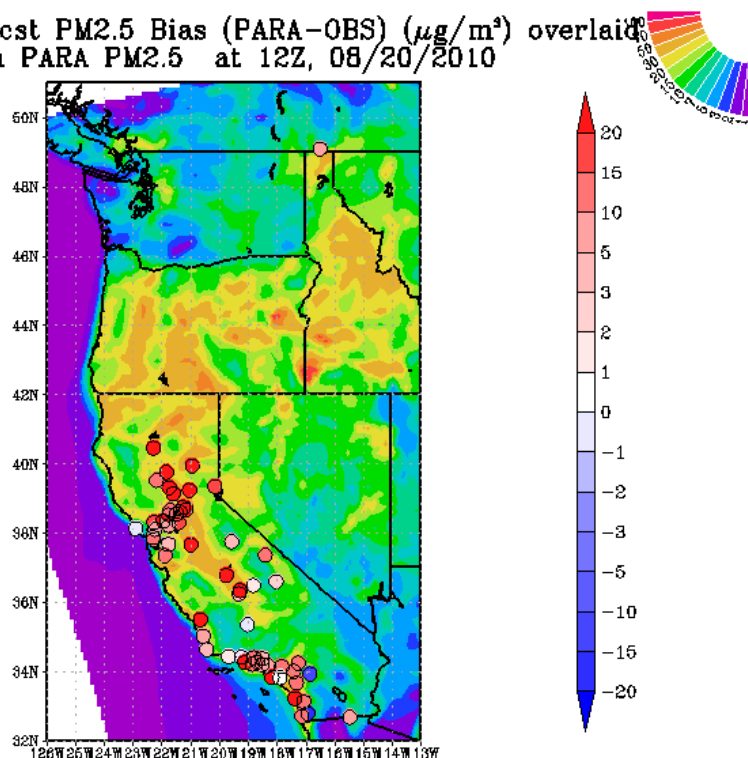


Test2 (Combined) 8-hr max 01SEP2010



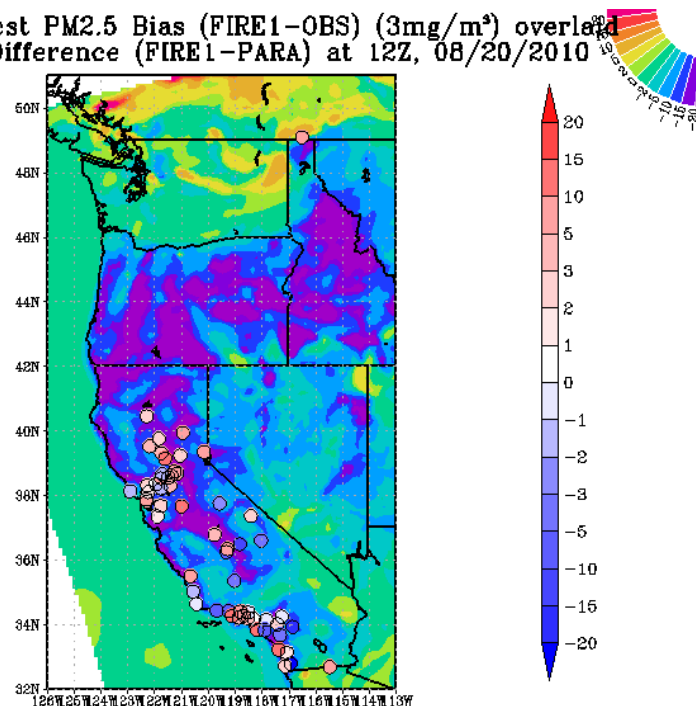
# R-T Developmental CMAQ fire emission runs

PARA 12Z-Fcst PM2.5 Bias (PARA-OBS) ( $\mu\text{g}/\text{m}^3$ ) overlaid  
on PARA PM2.5 at 12Z, 08/20/2010



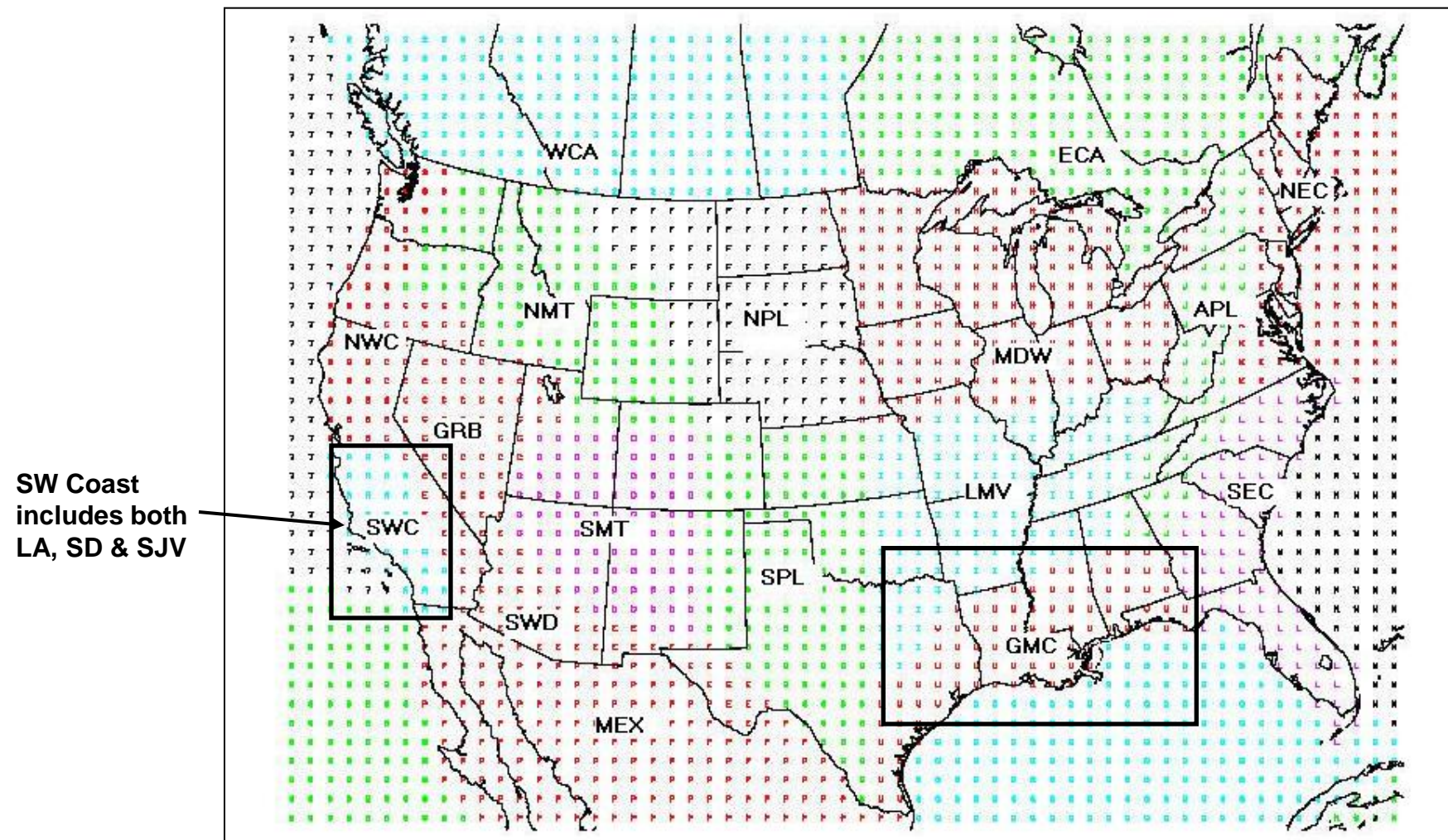
**Color fill: Experimental run**  
**Circles: Exp. Forecast - obs**

FIRE1 12Z-Fcst PM2.5 Bias (FIRE1-OBS) ( $3\text{mg}/\text{m}^3$ ) overlaid  
on PM2.5 Difference (FIRE1-PARA) at 12Z, 08/20/2010



**Color fill: Fire fcst - exp. fcst**  
**Circles: Fire Forecast - obs**

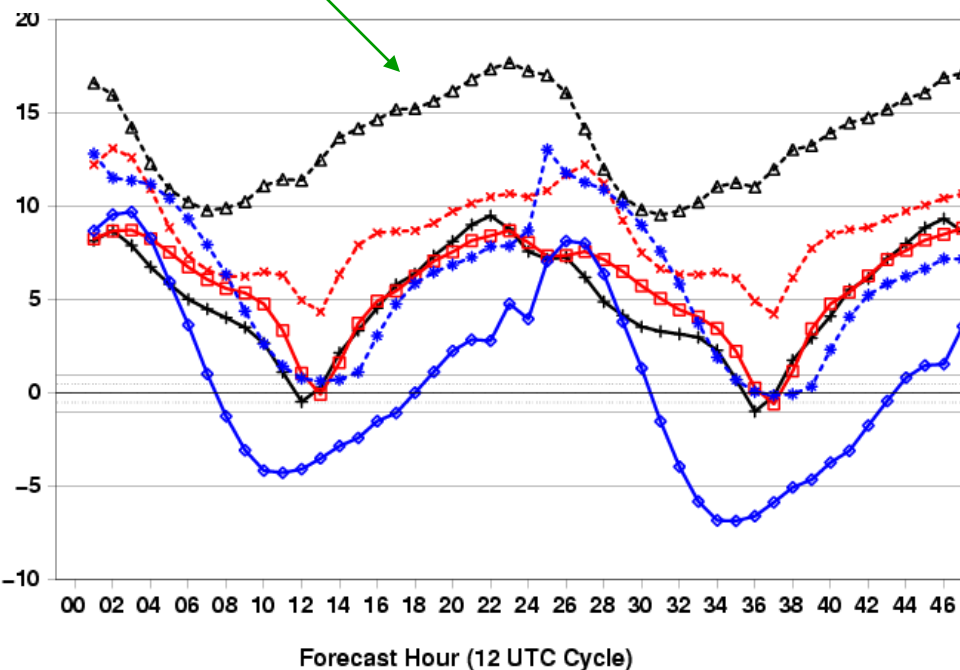
# Verification Sub-domains



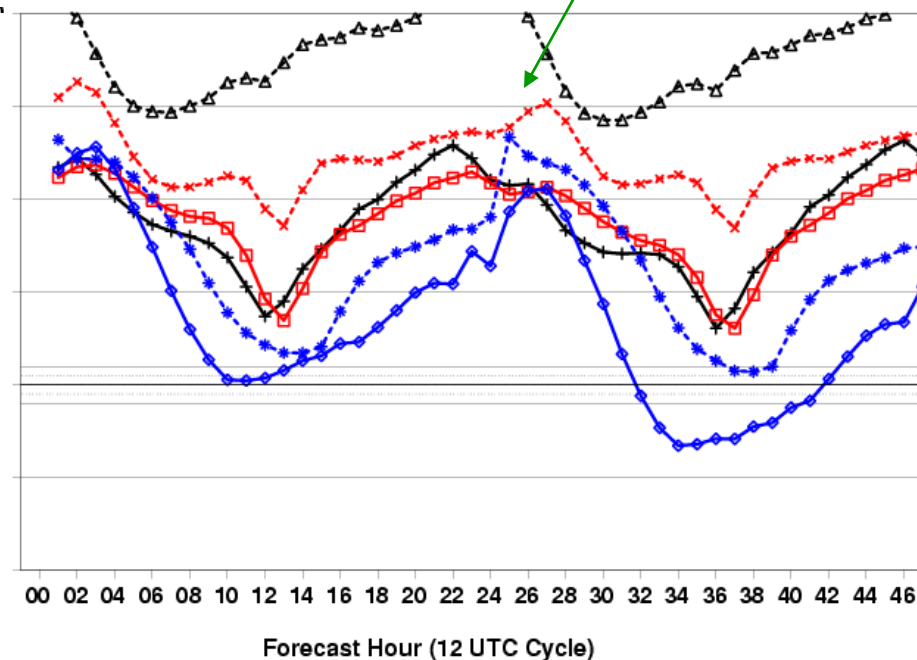
# NCEP Air Quality Forecast 2010 Verification (1 hr avg ozone bias)



Production



Experimental



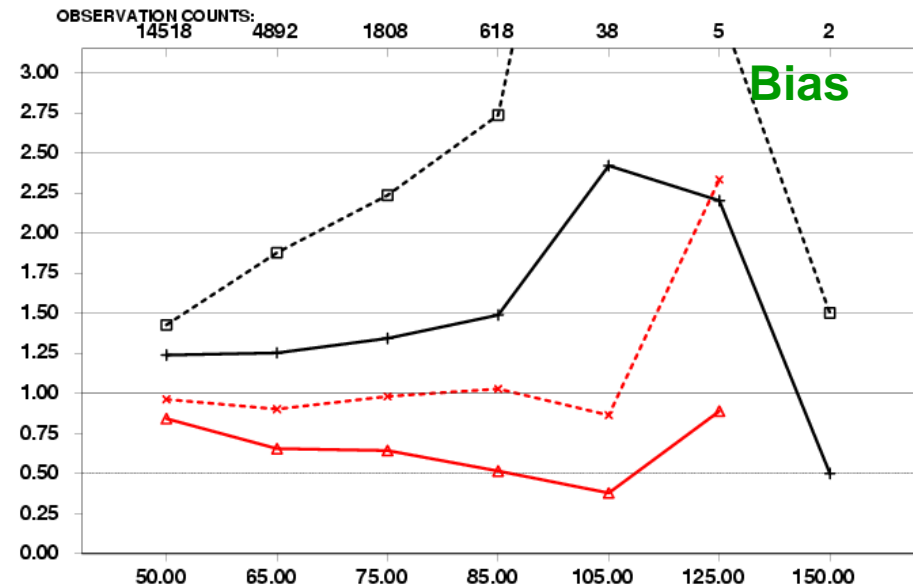
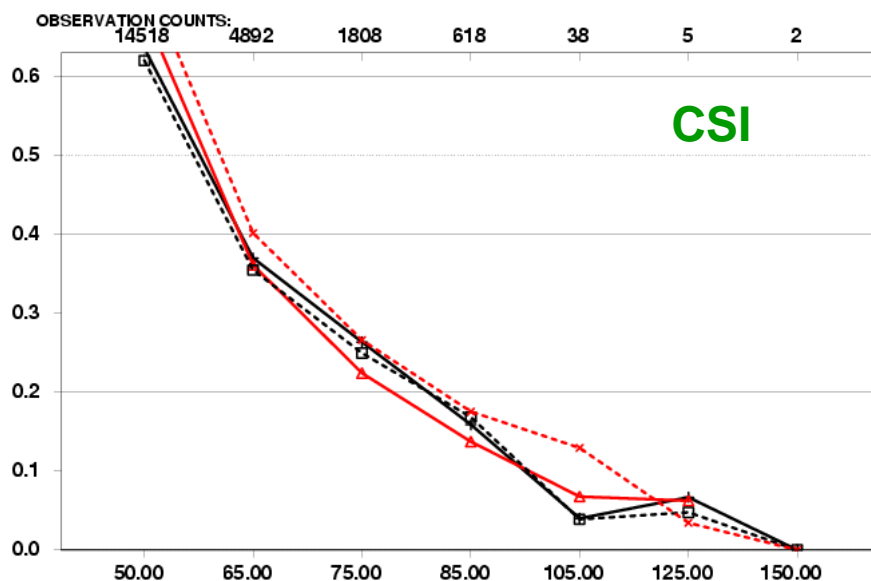
## Experimental Run:

- Almost the same for NW and Mid West
- Higher for NE, SE and Low Miss Valley (increase positive bias)
- Higher for SW (improve negative bias)

# NCEP Air Quality Forecast 2010 Verification (Daily 1h Max O3 Threshold performance Production vs Experimental, East vs West )

from 20100601 to 20100719 for 48 Hour Forecasts

—+—	AQMPROD VARB: OZMX/1	RGN: East-US LVL: SFC
—△—	AQMPROD VARB: OZMX/1	RGN: West-US LVL: SFC
- -+ - -	AQM PARA VARB: OZMX/1	RGN: East-US LVL: SFC
- -△ - -	AQM PARA VARB: OZMX/1	RGN: West-US LVL: SFC



Exp run is Improved over Western U.S.  
But positive bias is large over East

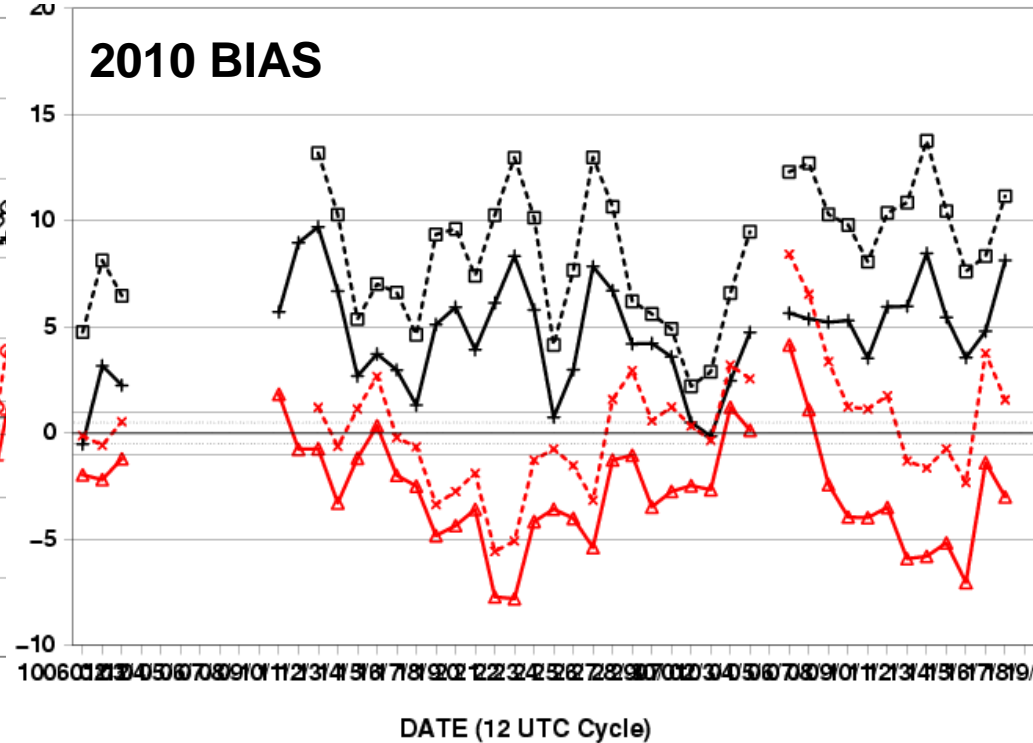
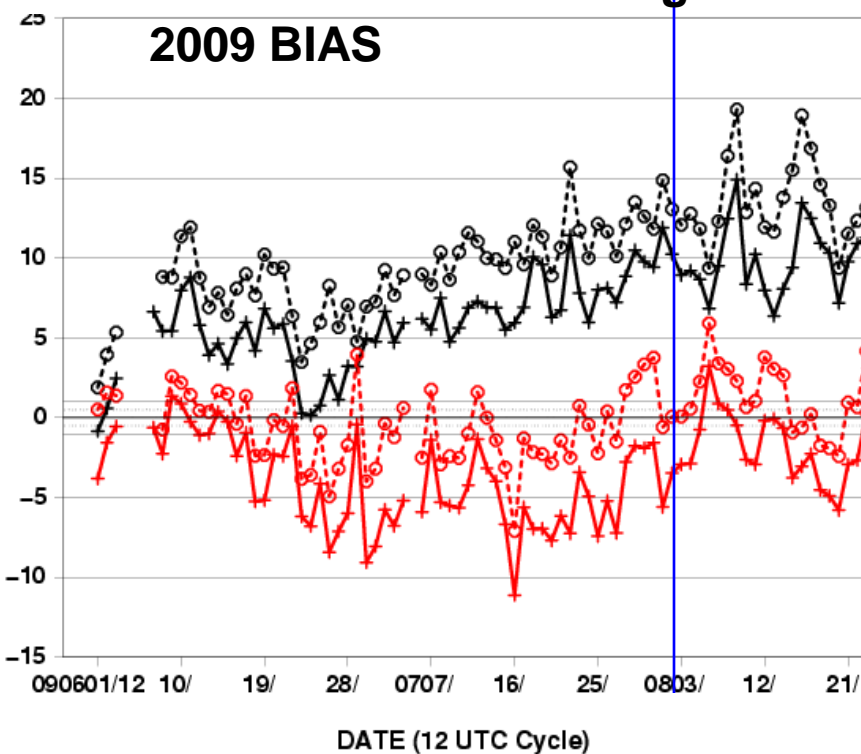
# NCEP Air Quality Forecast 2009-2010 Verification (1 hr Max ozone East vs West U.S. for Day 2)

—+—	AQMPROD VARB: OZMX/1	RGN: East-US
—+—	AQMPROD VARB: OZMX/1	RGN: West-US
- - -○-	AQM PARA VARB: OZMX/1	RGN: East-US
- - -○-	AQM PARA VARB: OZMX/1	RGN: West-US

Aug. 1

2009 BIAS

2010 BIAS

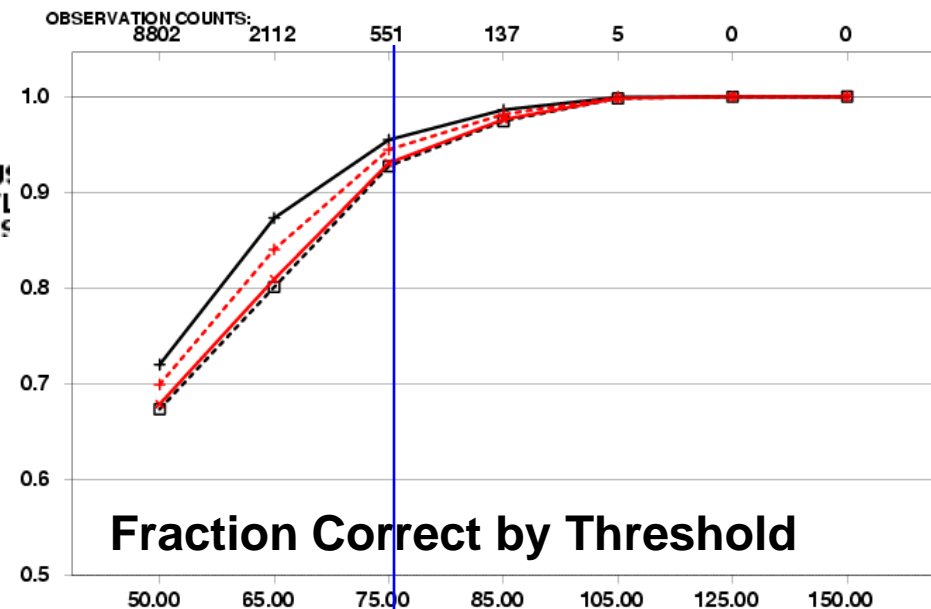
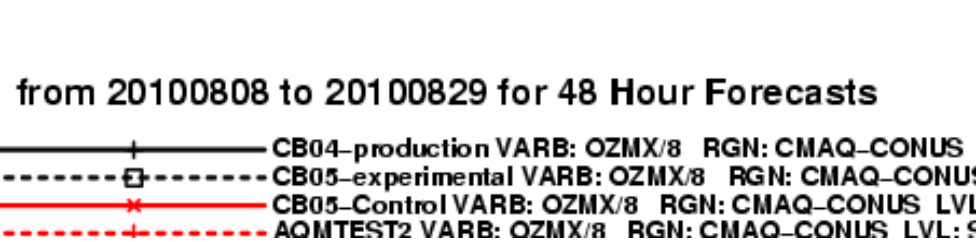
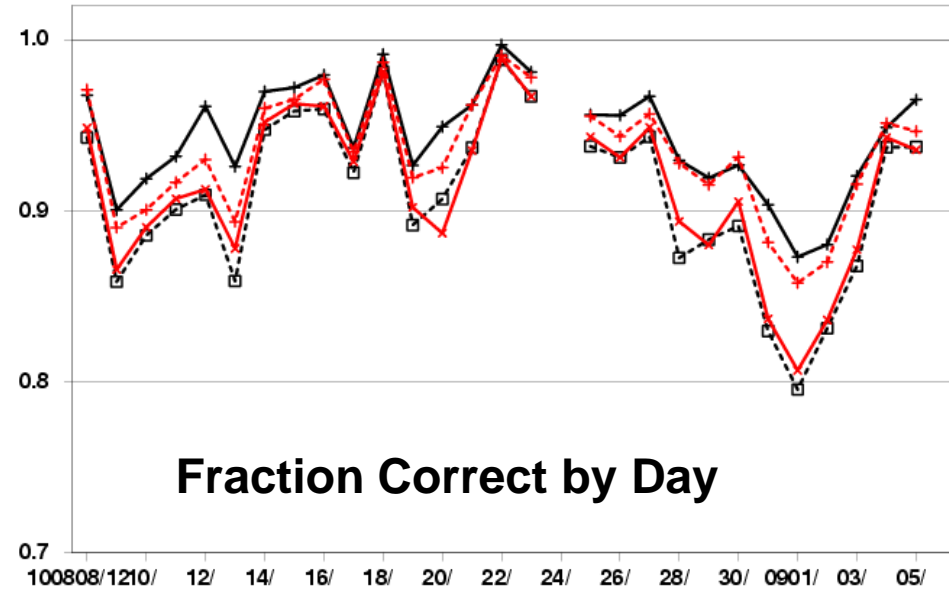
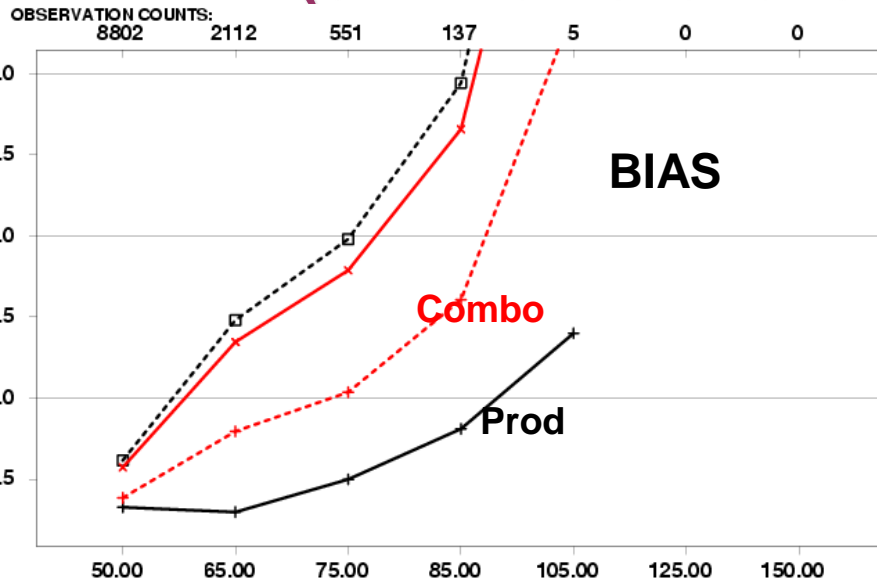


2009: Increasing Bias trend as Summer progressed for Eastern U.S.  
2010: No increased bias so far.

# DEVELOPMENTAL RESEARCH RUN EVALUATIONS

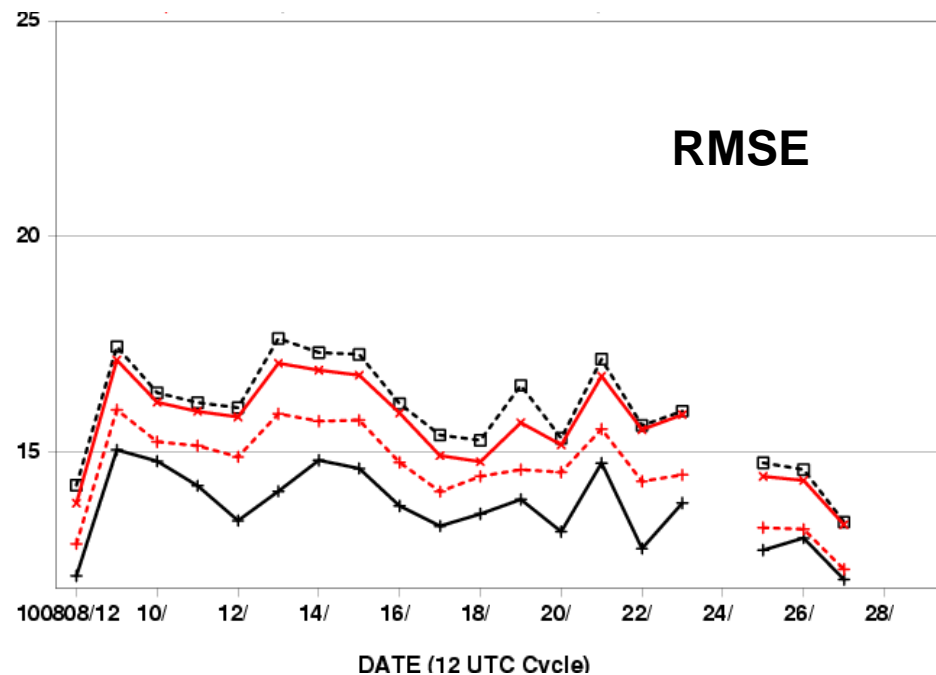
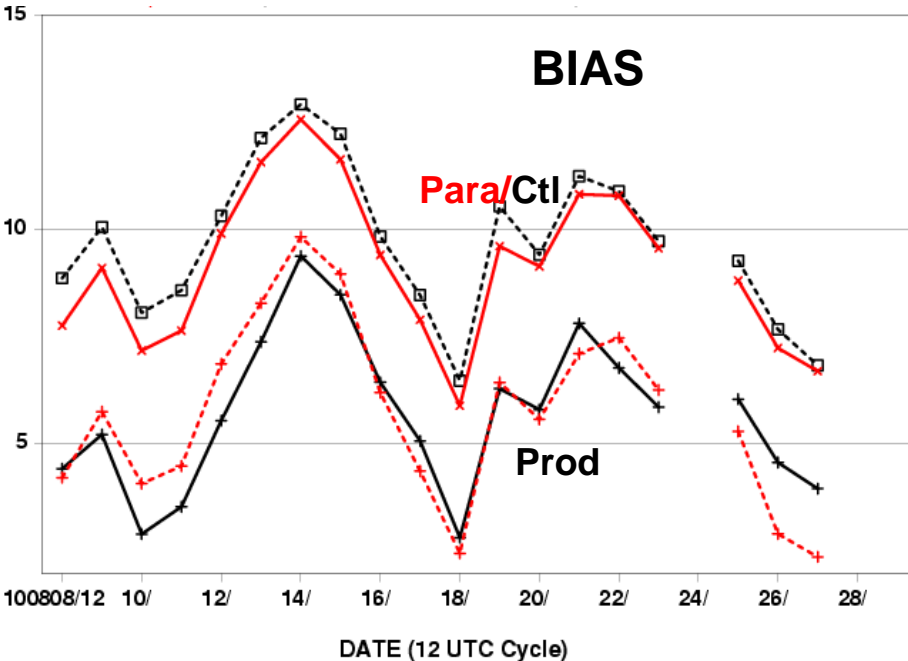
- Production CB04(black solid) vs Experimental CB05 (red solid) vs
  - **Developmental bundled (red dashed)** run:
    - M-O similarity theory deposition velocity
    - Improved canopy resistance
    - Minimum PBL height
    - GEOS-5 Chem dynamic LBCs
- August 8, 2010 → Sept. 7, 2010 12 UTC Cycle
- Day 2 8 hr avg daily maximum & (diurnal 1 hr avg) ozone forecasts
  - Fraction correct by threshold & >75 ppb
  - Bias by threshold and diurnal time-series
  - RMSE and diurnal time-series
- Regions:
  - CONUS, Eastern U.S., Western U.S.
  - NEC, SEC, MDW, LMV, NWC, SWC

# NCEP Air Quality Research Forecast 2010 Verification (8 hr Max ozone CONUS Errors for Day 2)



- Combination run improved compared to experimental & Control CB05
- Fraction correct > 90%

# NCEP Air Quality Research Forecast 2010 Verification (Daily 8 hr Max ozone CONUS Errors for Day 2)



from 20100808 to 20100829 for 48 Hour Forecasts

—+— CB04—production VARB: OZMX/8 RGN: CMAQ—CONUS  
 - - - □ - - - CB05—experimental VARB: OZMX/8 RGN: CMAQ—CONUS  
 —x— CB05—Control VARB: OZMX/8 RGN: CMAQ—CONUS LVL  
 - - - + - - - AQMTEST2 VARB: OZMX/8 RGN: CMAQ—CONUS LVL: 9

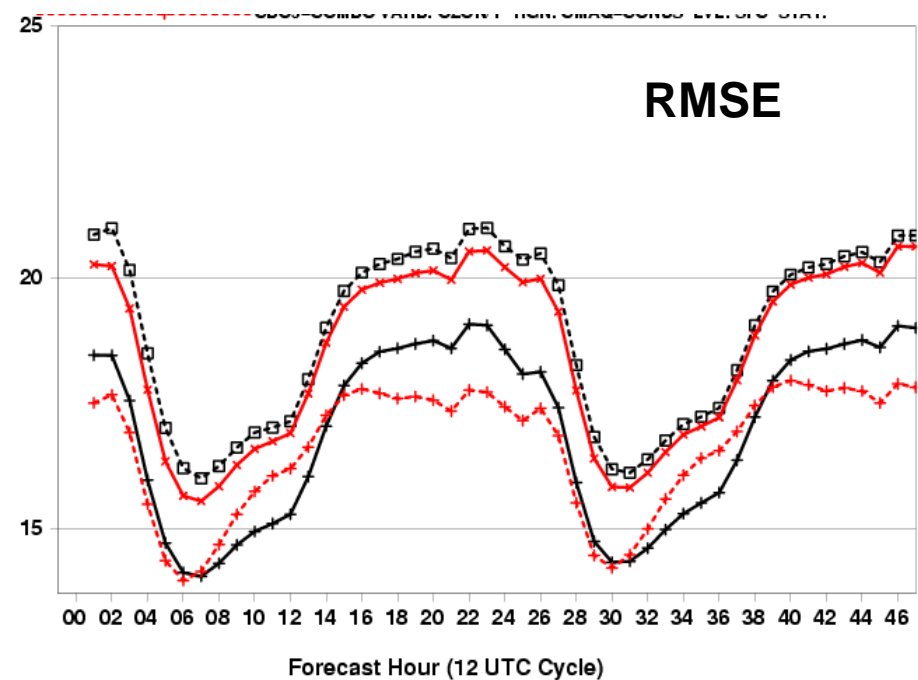
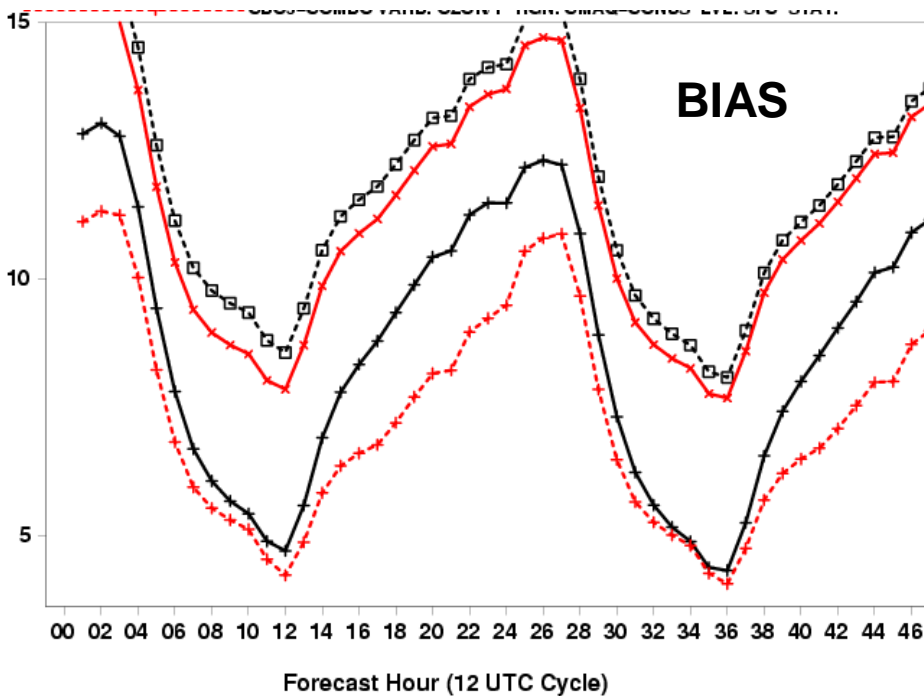
- Combination run improved compared to experimental/Para & Control CB05
- Similar behavior to prod run
- RMSE slightly worse than Prod

# NCEP Air Quality Research Forecast 2010 Verification (Diurnal 1 hr Avgd ozone CONUS Errors)

## SFC OZON/1 BIAS

averaged by fcst hrs from 20100808 to 20100907

—+— CB04—production VARB: OZON/1 RGN: East-US LVL: SFC STAT:  
- - - □ - - - CB05—experimental VARB: OZON/1 RGN: East-US LVL: SFC STAT:  
—+— CB05—Control VARB: OZON/1 RGN: East-US LVL: SFC STAT:  
- - - + - - - CBO5—COMBO VARB: OZON/1 RGN: East-US LVL: SFC STAT:

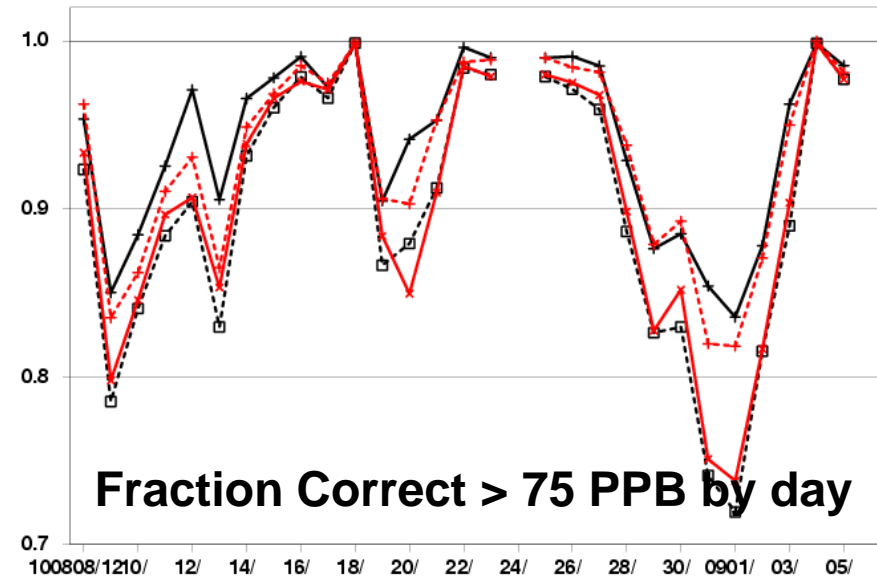
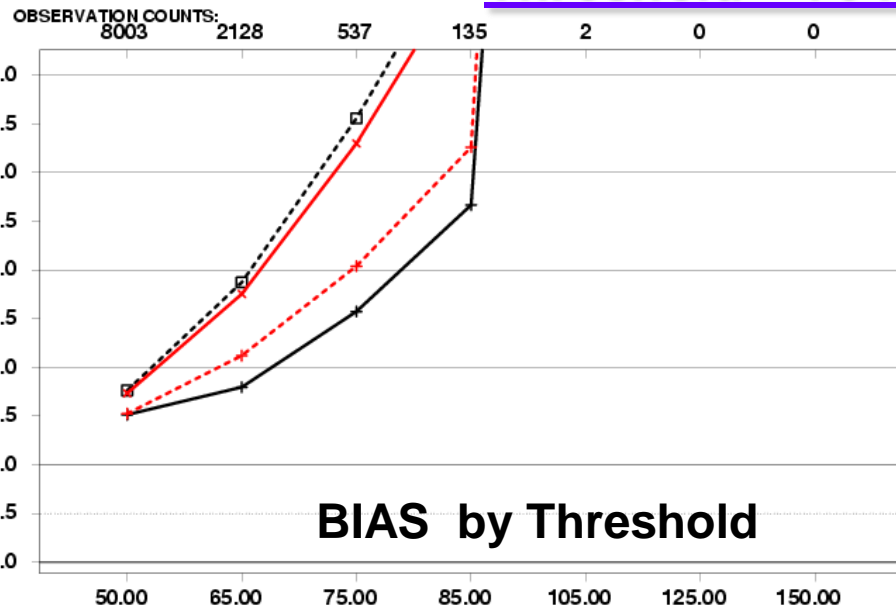


- Overall, Combination run outperforms Production run

# NCEP Air Quality Research Forecast 2010 Verification

## Daily 8 hr Max ozone Eastern U.S. Errors for Day 2

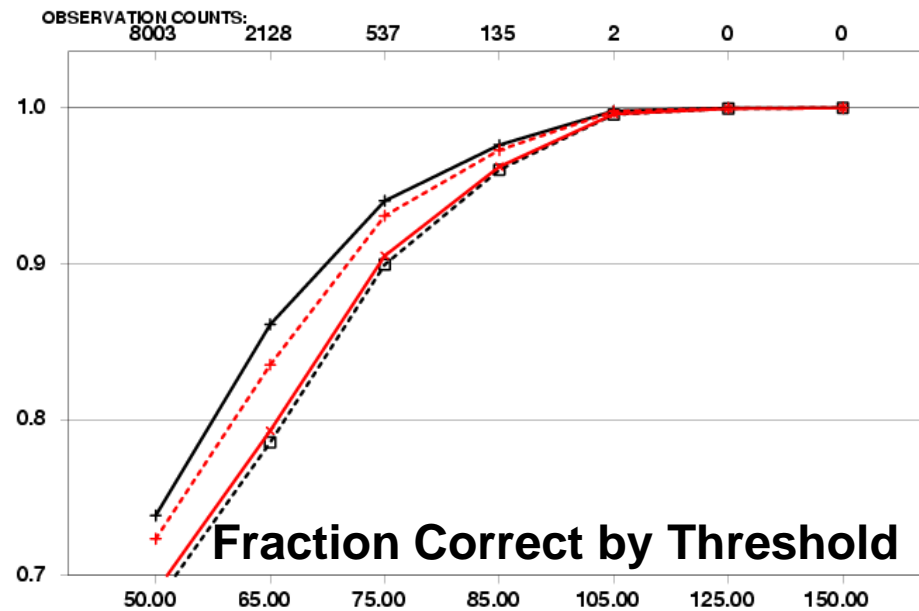
### Threshold > 75 PPB & by threshold



from 20100808 to 20100829 for 48 Hour Forecasts

—+— CB04—production VARB: OZMX/8 RGN: CMAQ-CONUS  
 - - - □ - - - CB05—experimental VARB: OZMX/8 RGN: CMAQ-CONUS  
 —x— CB05—Control VARB: OZMX/8 RGN: CMAQ-CONUS LVL  
 - - - + - - - AQMTEST2 VARB: OZMX/8 RGN: CMAQ-CONUS LVL: 5

- Combination run (dashed red) similar or slightly worse than Prod run (black solid)
- Experimental run bias largest



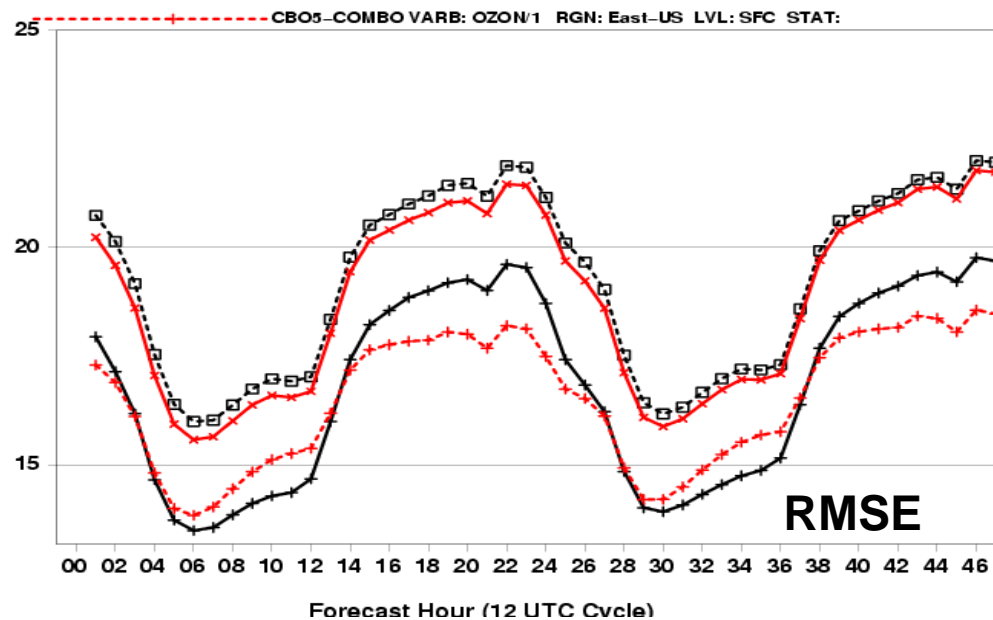
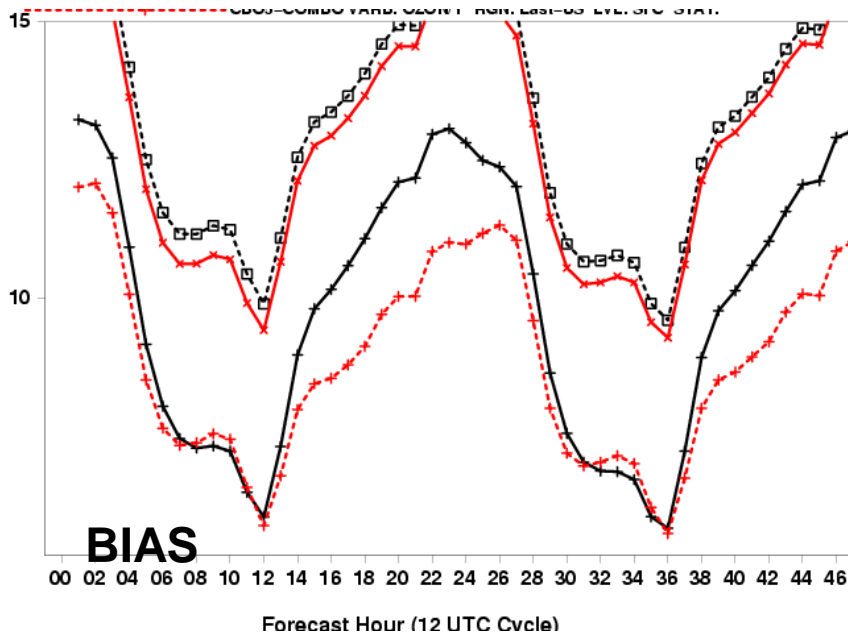
# NCEP Air Quality Research Forecast 2010 Verification

## Diurnal 1 hr avg Errors for Eastern U.S.

### SFC OZON/1 BIAS

averaged by fcst hrs from 20100808 to 20100907

—+— CB04—production VARB: OZON/1 RGN: East-US LVL: SFC STAT:  
- - - □ - - - CB05—experimental VARB: OZON/1 RGN: East-US LVL: SFC STAT:  
—+— CB05—Control VARB: OZON/1 RGN: East-US LVL: SFC STAT:  
- - - + - - - CBO5—COMBO VARB: OZON/1 RGN: East-US LVL: SFC STAT:

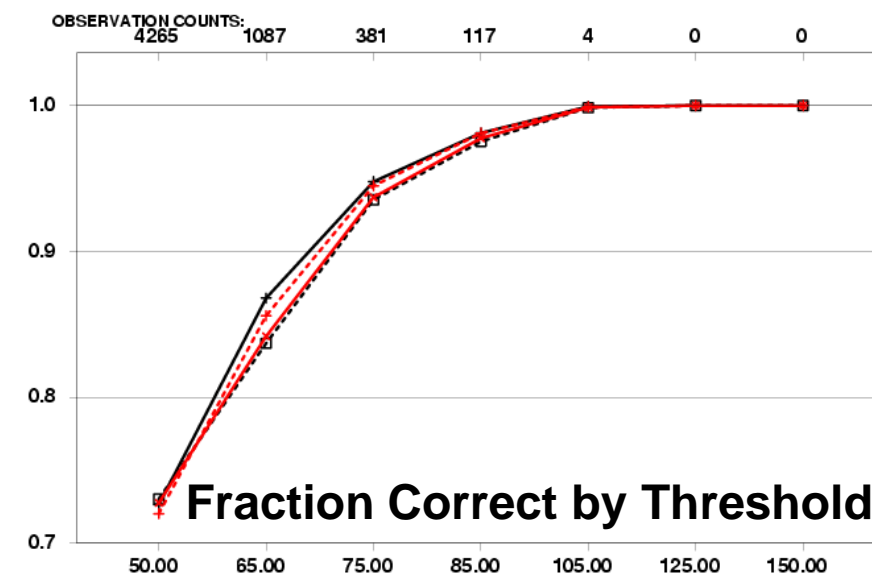
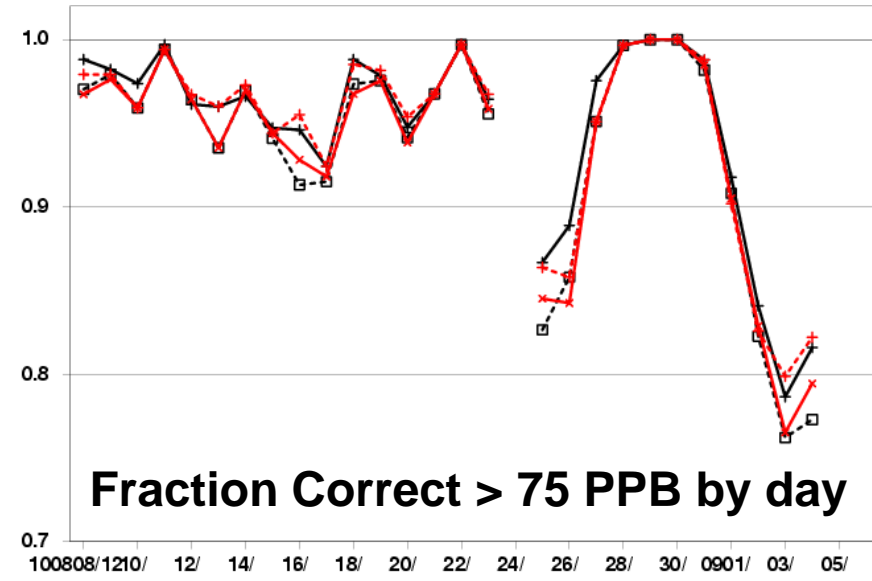
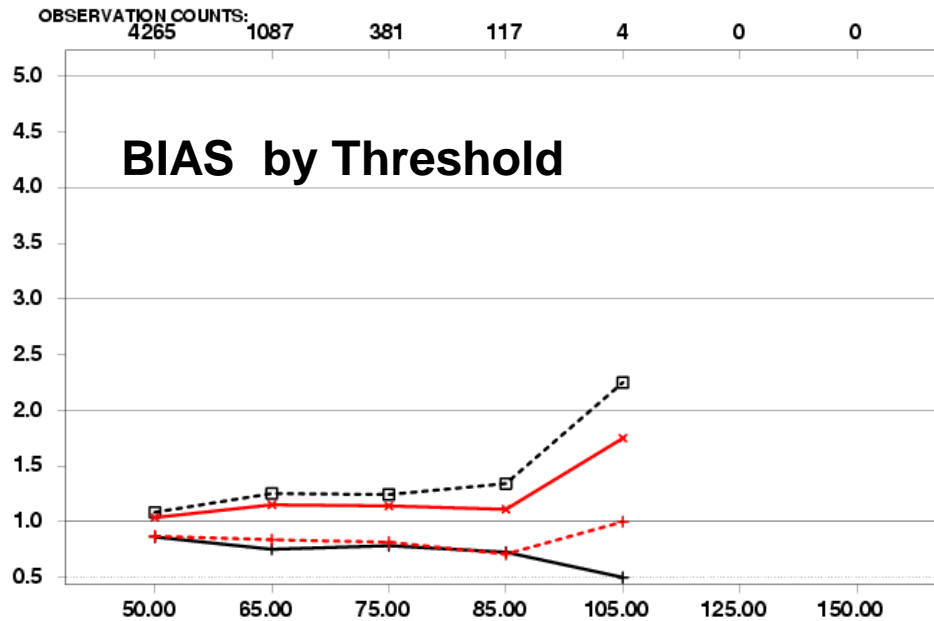


- Combination run (dashed red) Improved compared to Prod run(black solid)
- Experimental run bias often largest

# NCEP Air Quality Research Forecast 2010 Verification

Daily 8 hr Max ozone Western U.S. Errors for Day 2

Threshold > 75 PPB & by threshold



from 20100808 to 20100829 for 48 Hour Forecasts

—+— CB04—production VARB: OZMX/8 RGN: CMAQ-CONUS  
- - - □ - - - CB05—experimental VARB: OZMX/8 RGN: CMAQ-CONUS  
—x— CB05—Control VARB: OZMX/8 RGN: CMAQ-CONUS LVL: 9  
- - - + - - - AQMTEST2 VARB: OZMX/8 RGN: CMAQ-CONUS LVL: 9

- Combination run (dashed red) similar to Prod run (black solid)
- Experimental run bias often largest

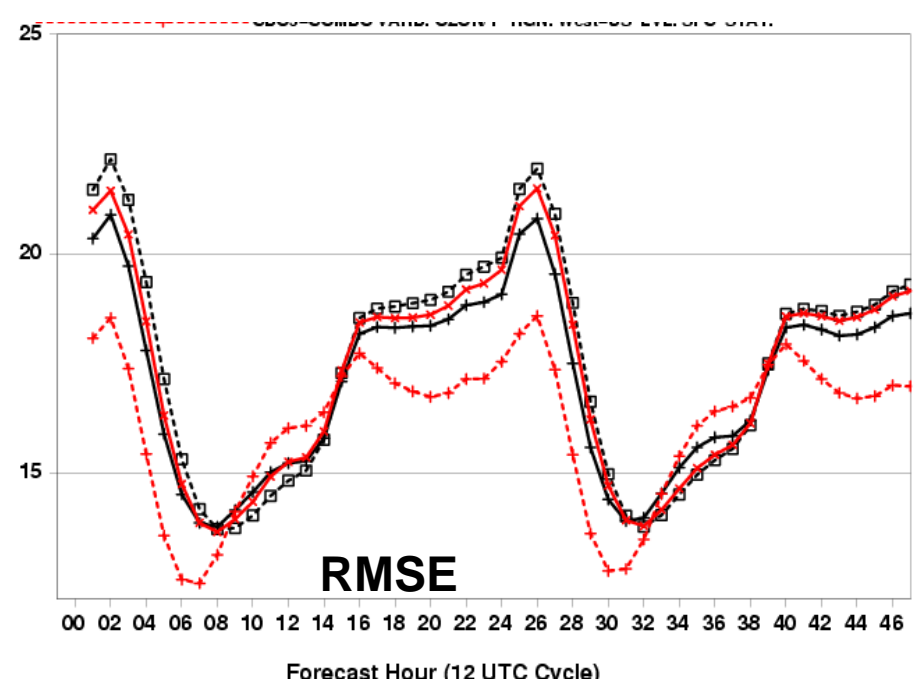
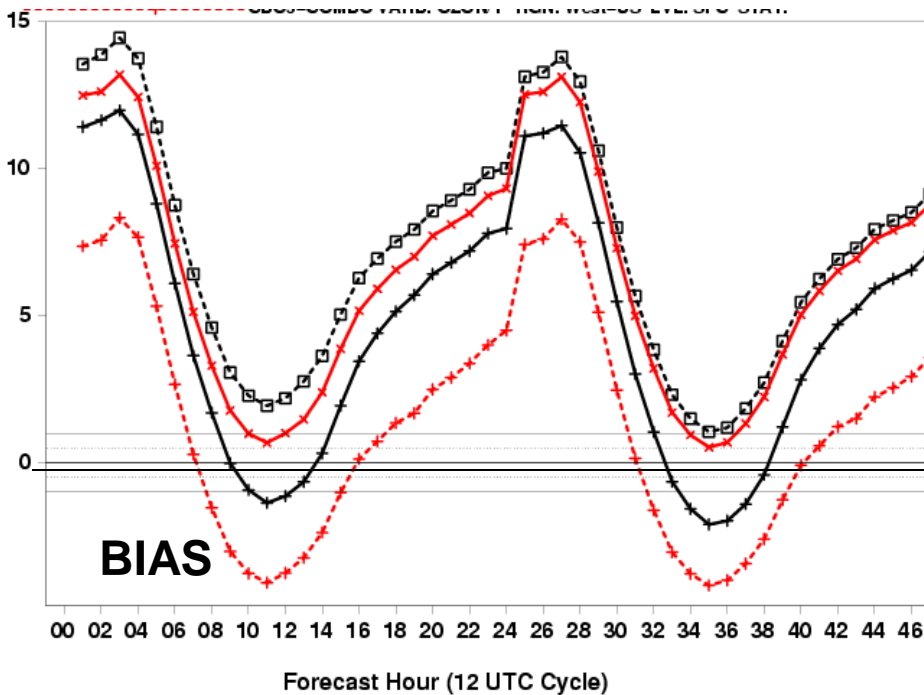
# NCEP Air Quality Research Forecast 2010 Verification

## Diurnal 1 hr avg Errors for Western U.S.

### SFC OZON/1 BIAS

averaged by fcst hrs from 20100808 to 20100907

— CB04—production VARB: OZON/1 RGN: East-US LVL: SFC STAT:  
 - - - CB05—experimental VARB: OZON/1 RGN: East-US LVL: SFC STAT:  
 — CB05—Control VARB: OZON/1 RGN: East-US LVL: SFC STAT:  
 - - - CB05—COMBO VARB: OZON/1 RGN: East-US LVL: SFC STAT:

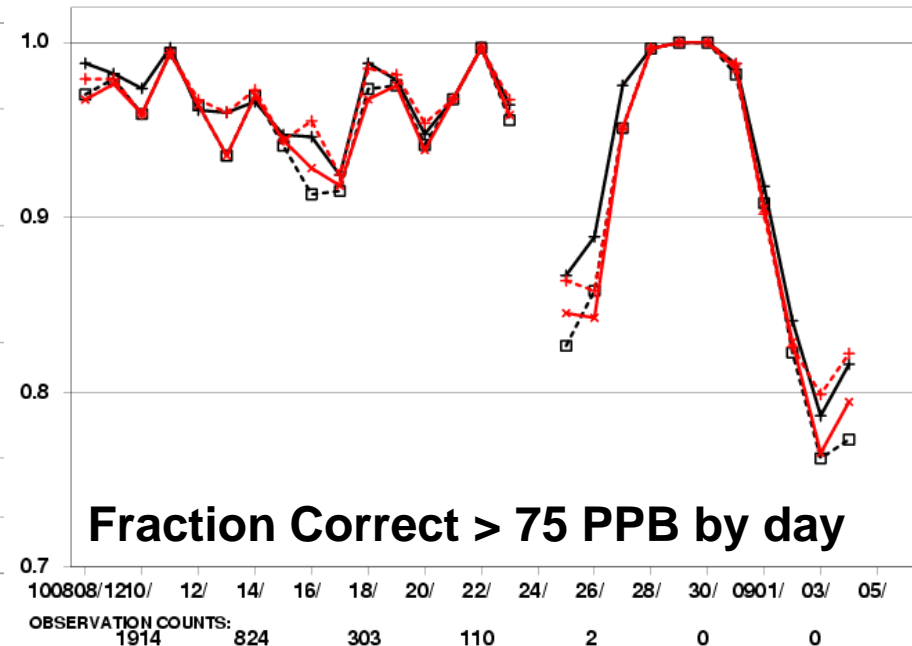
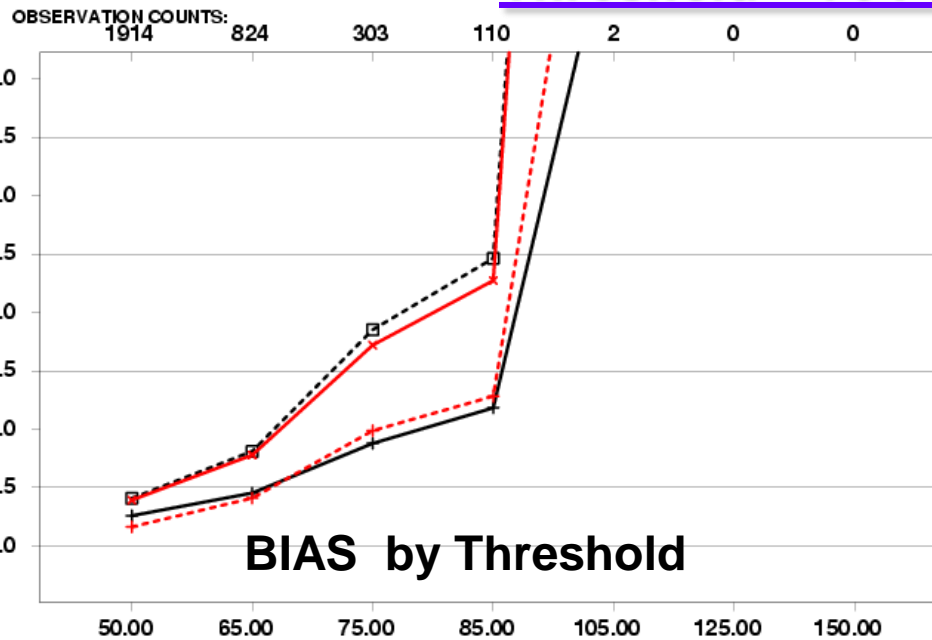


- Combination run daytime under-prediction worse
- However, RMSE improved in general except betw 22-02 UTC

# NCEP Air Quality Research Forecast 2010 Verification

## Daily 8 hr Max ozone NE U.S. Errors for Day 2

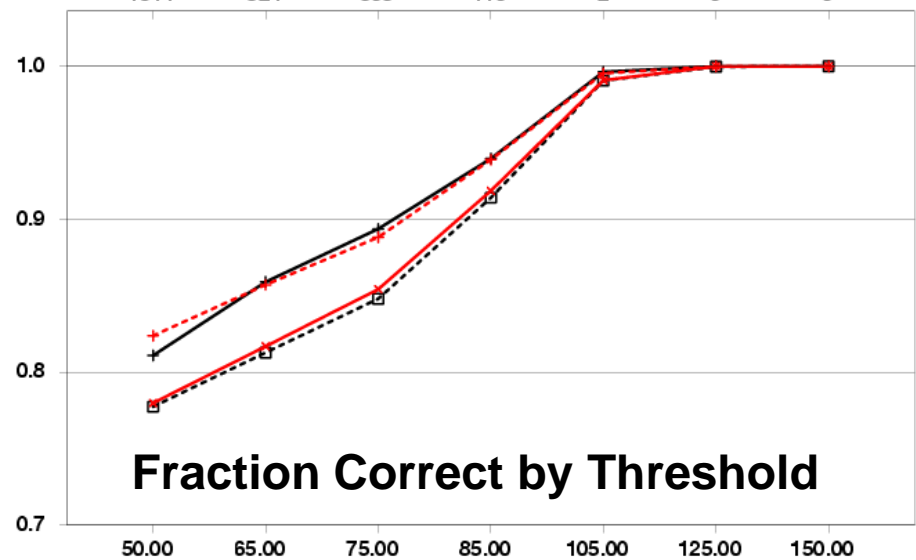
Threshold > 75 PPB & by threshold



from 20100808 to 20100829 for 48 Hour Forecasts

—+— CB04—production VARB: OZMX/8 RGN: CMAQ—CONUS  
 - - - □ - - - CB05—experimental VARB: OZMX/8 RGN: CMAQ—CONUS  
 — x — CB05—Control VARB: OZMX/8 RGN: CMAQ—CONUS LVL  
 - - - + - - - AQMTEST2 VARB: OZMX/8 RGN: CMAQ—CONUS LVL: 5

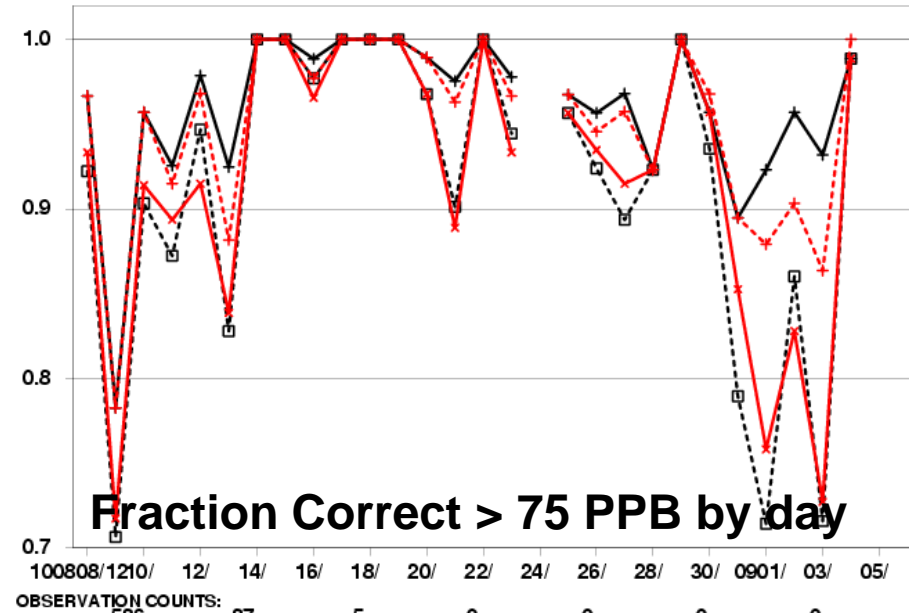
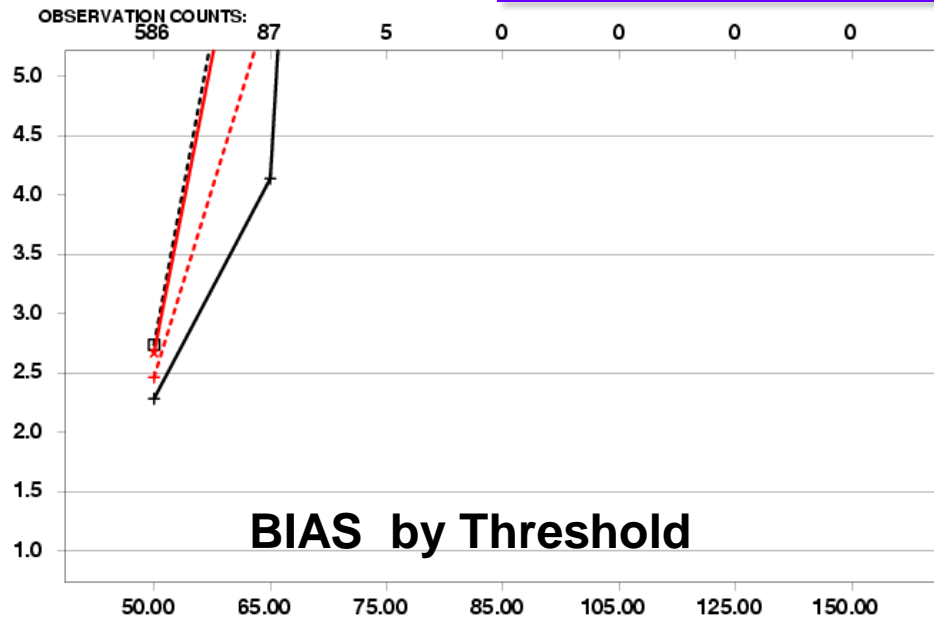
- Combination run (dashed red) similar to Prod run (black solid)
- Experimental run bias often largest



# NCEP Air Quality Research Forecast 2010 Verification

Daily 8 hr Max ozone **SE U.S.** Errors for Day 2

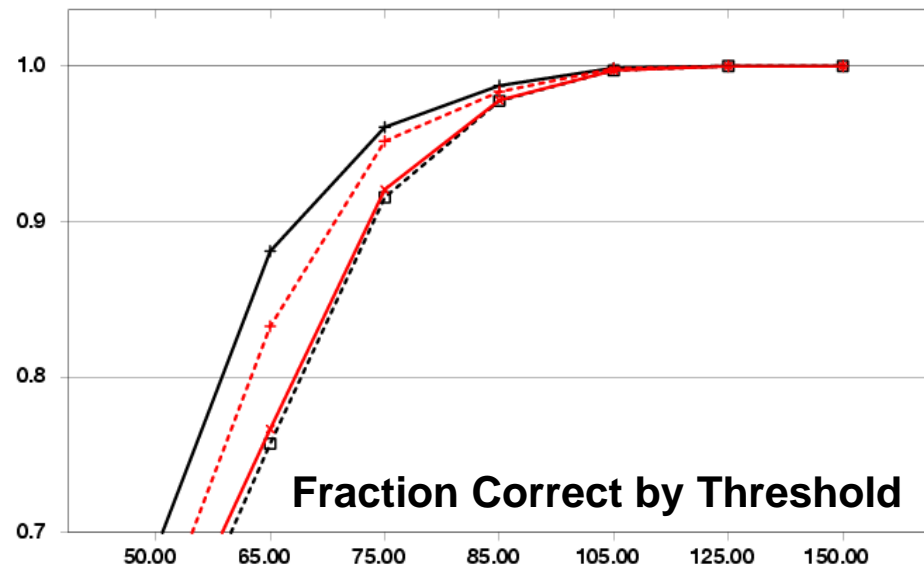
Threshold > 75 PPB & by threshold



from 20100808 to 20100829 for 48 Hour Forecasts

—+— CB04—production VARB: OZMX/8 RGN: CMAQ-CONUS  
 - - - □ - - - CB05—experimental VARB: OZMX/8 RGN: CMAQ-CONUS  
 —x— CB05—Control VARB: OZMX/8 RGN: CMAQ-CONUS LVL: 5  
 - - - + - - - AQMTEST2 VARB: OZMX/8 RGN: CMAQ-CONUS LVL: 5

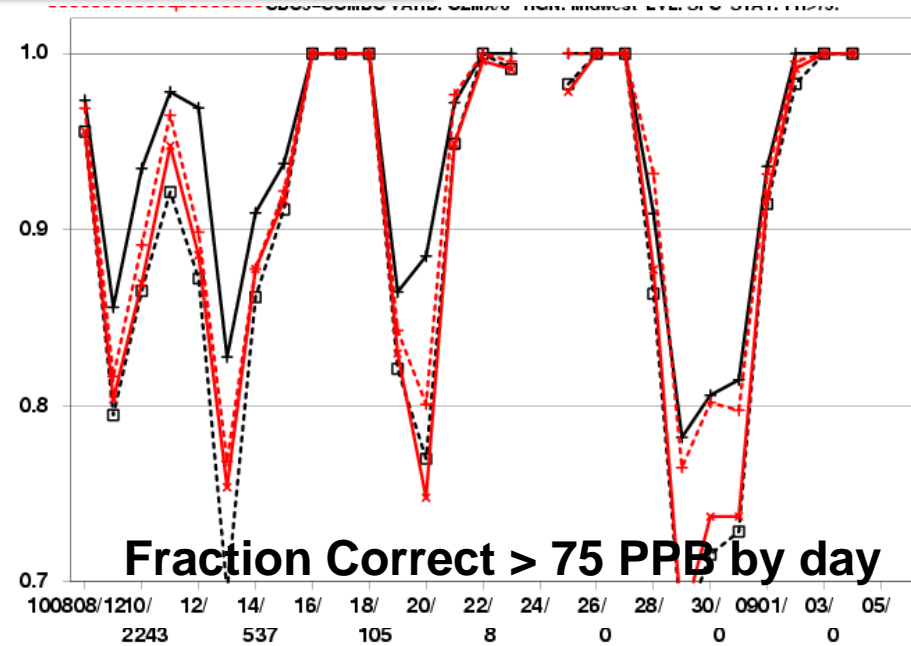
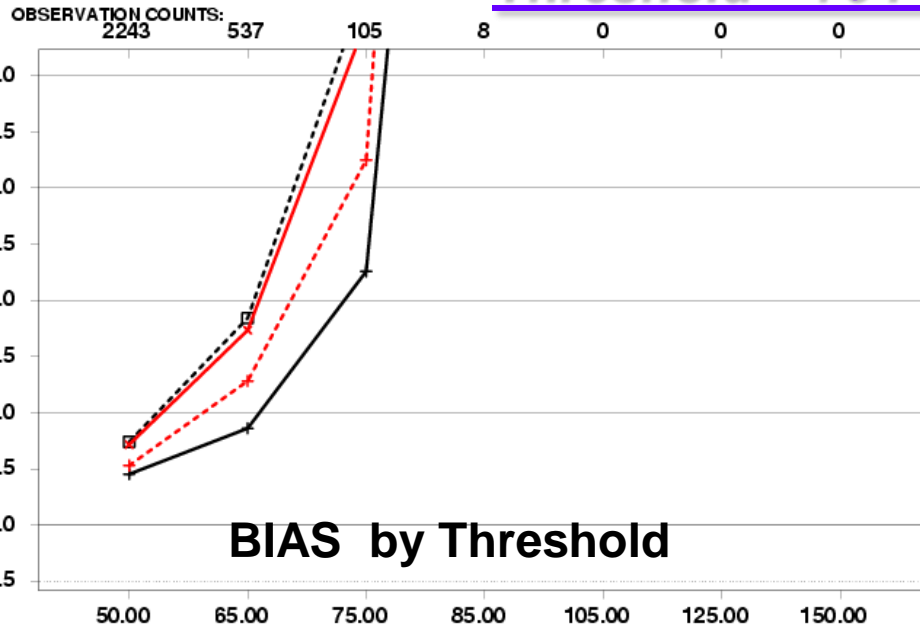
- Not enough cases for SEC
- COMBO & Prod similar at 75 PPB threshold



# NCEP Air Quality Research Forecast 2010 Verification

## Daily 8 hr Max ozone Mid West Errors for Day 2

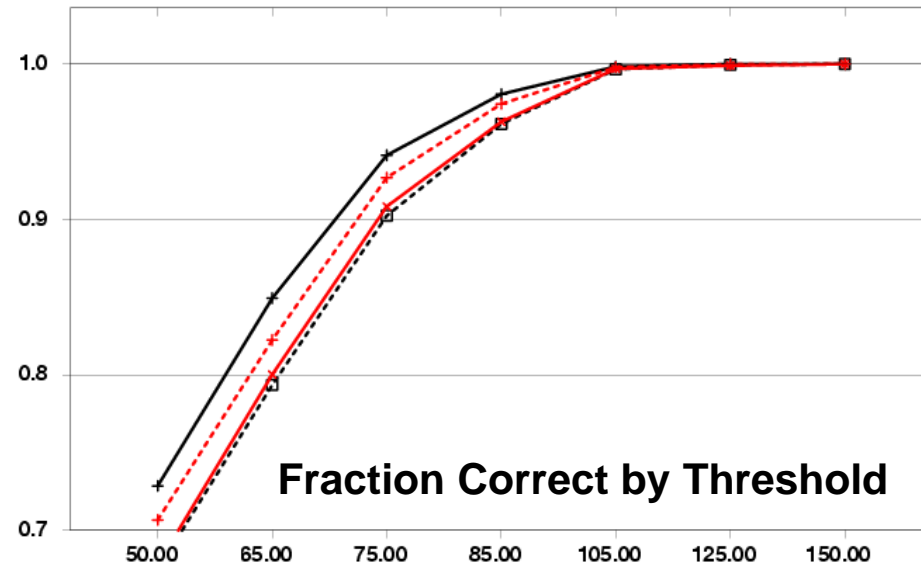
Threshold > 75 PPB & by threshold



from 20100808 to 20100829 for 48 Hour Forecasts

—+— CB04—production VARB: OZMX/8 RGN: CMAQ-CONUS  
 - - - □ - - - CB05—experimental VARB: OZMX/8 RGN: CMAQ-CONUS  
 — x — CB05—Control VARB: OZMX/8 RGN: CMAQ-CONUS LVL: 5  
 - - - + - - - AQMTEST2 VARB: OZMX/8 RGN: CMAQ-CONUS LVL: 5

- Combo Bias improved
- Combo FC lower

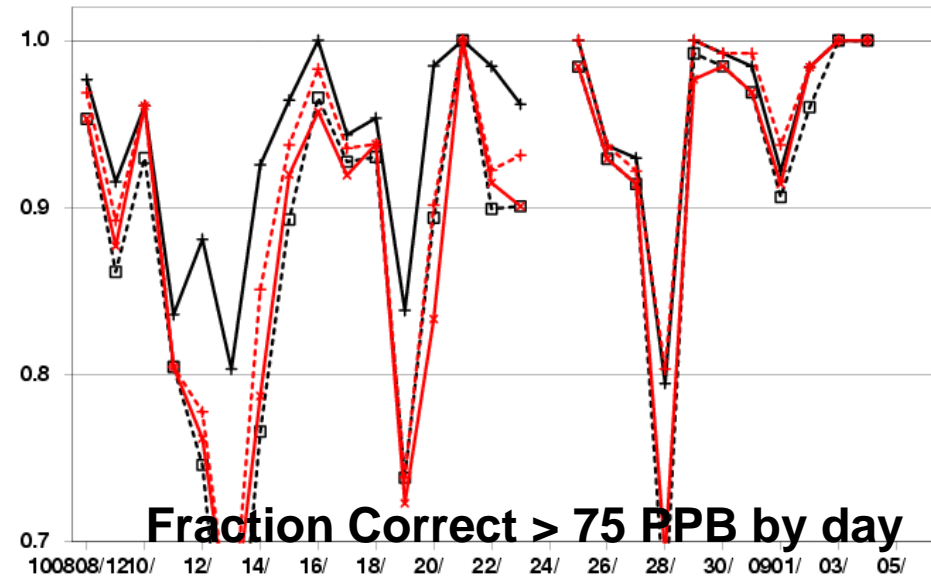
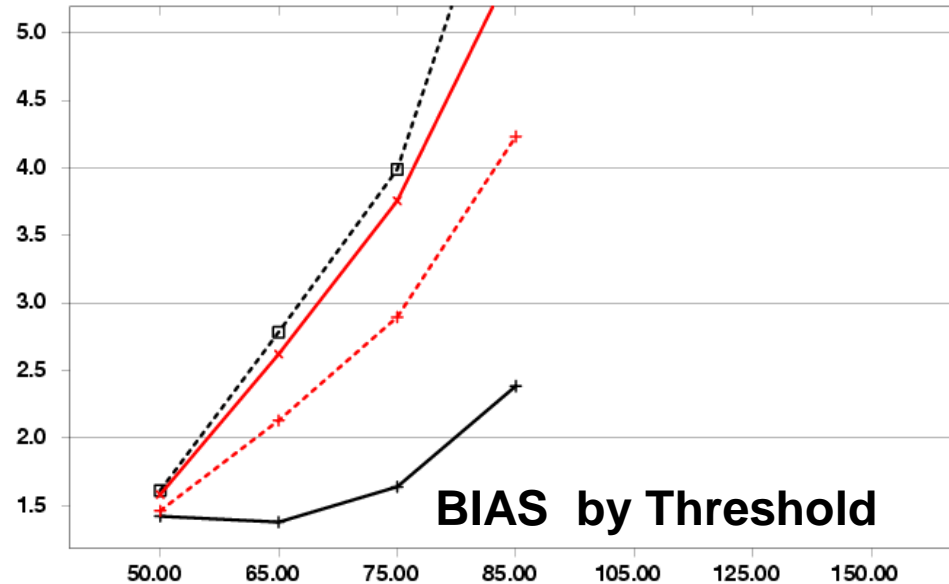


# NCEP Air Quality Research Forecast 2010 Verification

## Daily 8 hr Max ozone Lower Miss Valley Errors for Day 2

Threshold > 75 PPB & by threshold

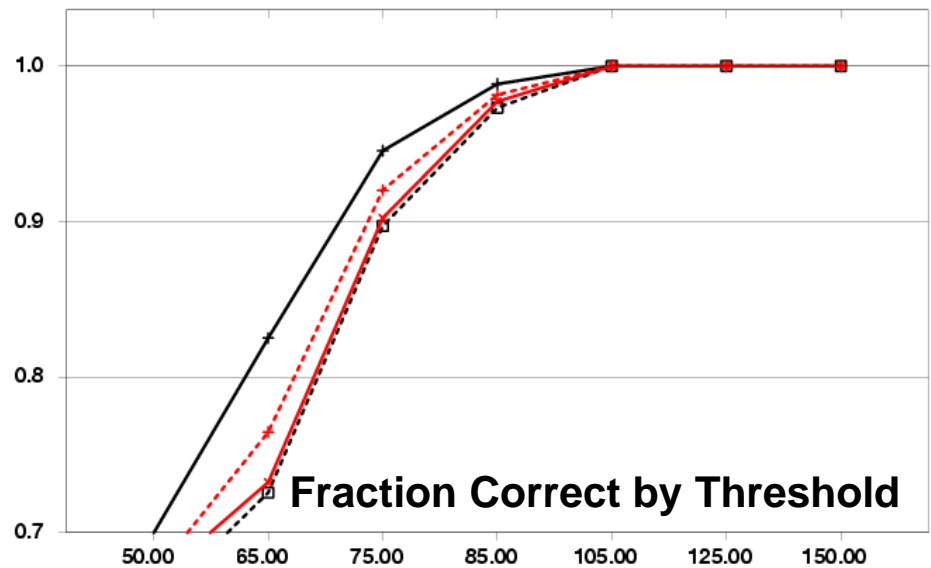
OBSERVATION COUNTS:  
1707 399 86 13 0 0 0



from 20100808 to 20100829 for 48 Hour Forecasts

—+— CB04—production VARB: OZMX/8 RGN: CMAQ-CONUS  
 - - - □ - - - CB05—experimental VARB: OZMX/8 RGN: CMAQ-CONUS  
 —x— CB05—Control VARB: OZMX/8 RGN: CMAQ-CONUS LVL: 5  
 - - - + - - - AQMTEST2 VARB: OZMX/8 RGN: CMAQ-CONUS LVL: 5

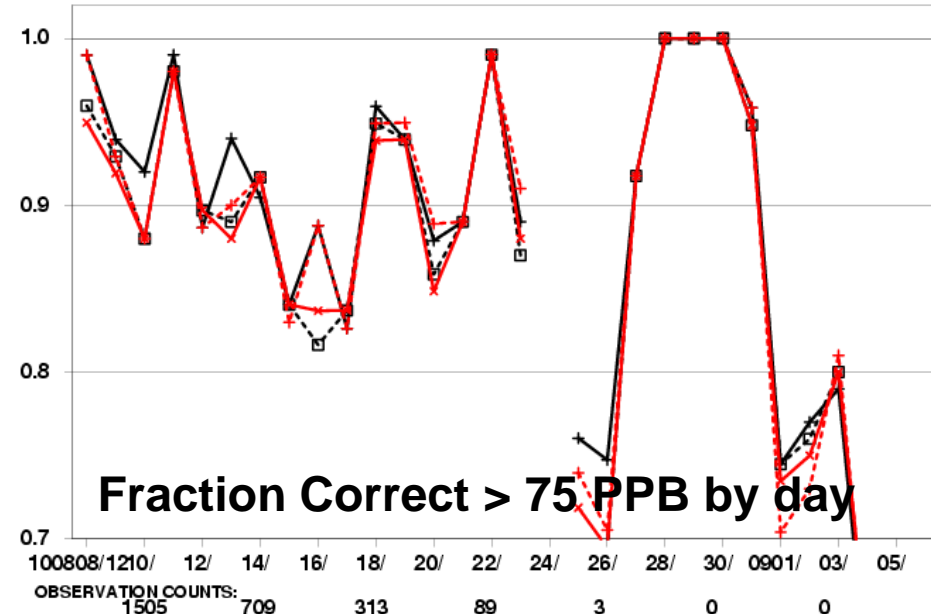
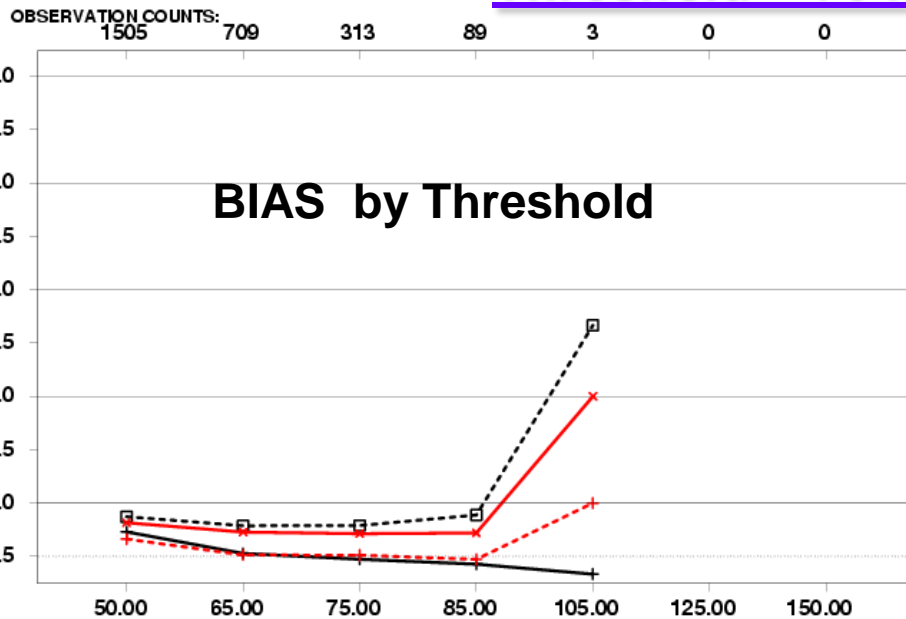
- Production Run Best
- Experimental run bias often largest



# NCEP Air Quality Research Forecast 2010 Verification

Daily 8 hr Max ozone **SWC** Errors for Day 2

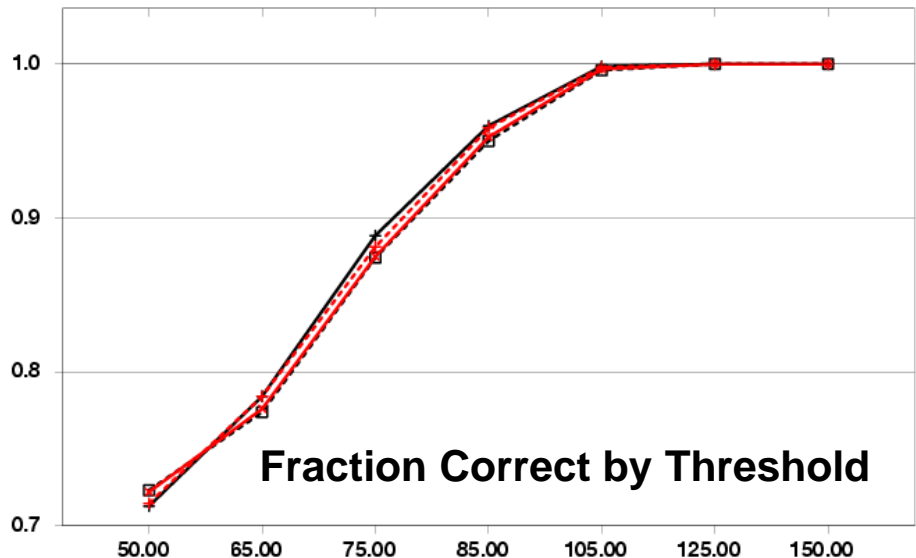
Threshold > 75 PPB & by threshold



from 20100808 to 20100829 for 48 Hour Forecasts

—+— CB04—production VARB: OZMX/8 RGN: CMAQ-CONUS  
 - - - x - - - CB05—experimental VARB: OZMX/8 RGN: CMAQ-CONUS  
 —+— CB05—Control VARB: OZMX/8 RGN: CMAQ-CONUS LVL: 5  
 - - - + - - - AQMTEST2 VARB: OZMX/8 RGN: CMAQ-CONUS LVL: 5

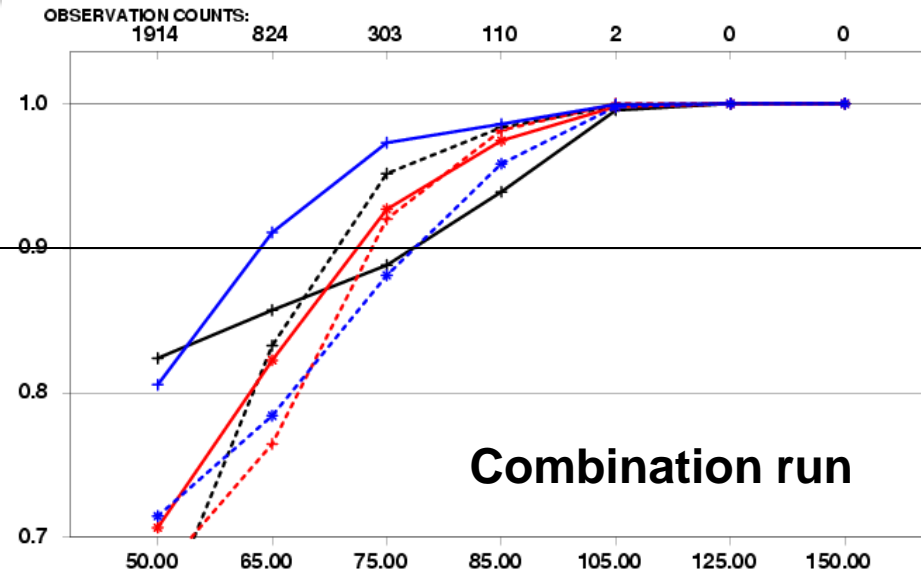
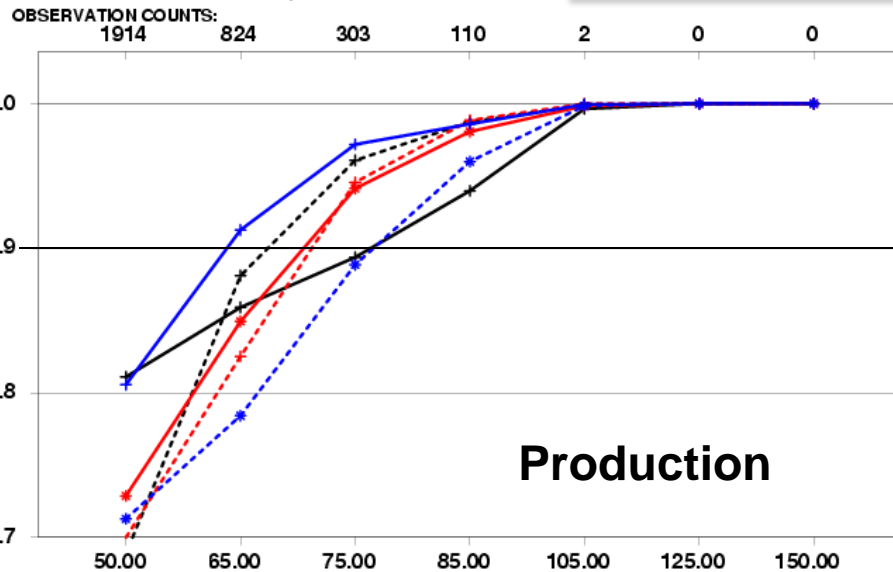
- Combination run similar to Prod run
- Experimental run best Bias



# NCEP Air Quality Research Forecast 2010 Verification

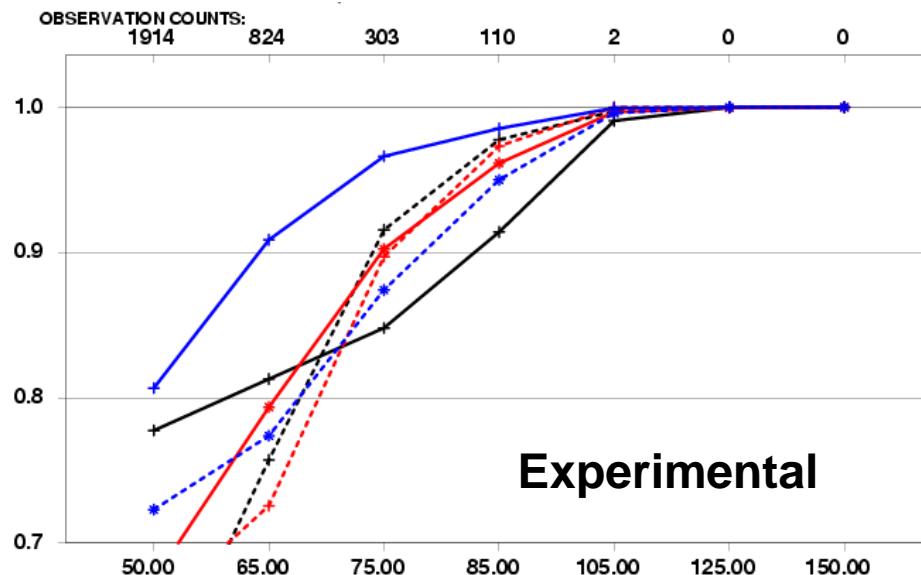
## Daily 8 hr Max ozone Errors for Day 2 (All Regions)

### Fraction Correct by threshold



from 20100808 to 20100907 for 48 Hour Forecasts

—+—	CB04-production VARB: OZMX/8	RGN: Northeast LVL
- -+ -	CB04-production VARB: OZMX/8	RGN: Southeast LVL
—*—	CB04-production VARB: OZMX/8	RGN: Midwest LVL
- -+ -	CB04-production VARB: OZMX/8	RGN: LMiss-Vall LV
—+—	CB04-production VARB: OZMX/8	RGN: NWest-Coast
- -+ -	CB04-production VARB: OZMX/8	RGN: SWEST-Coast

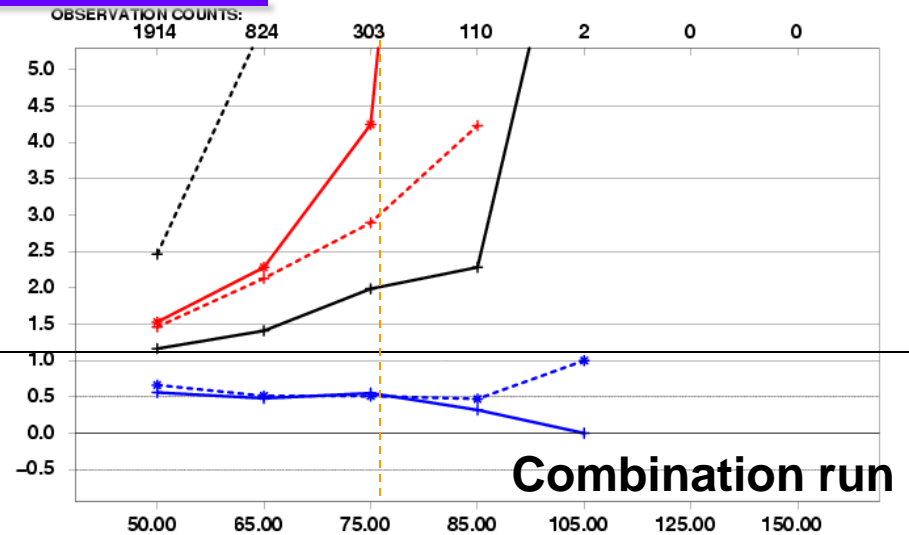
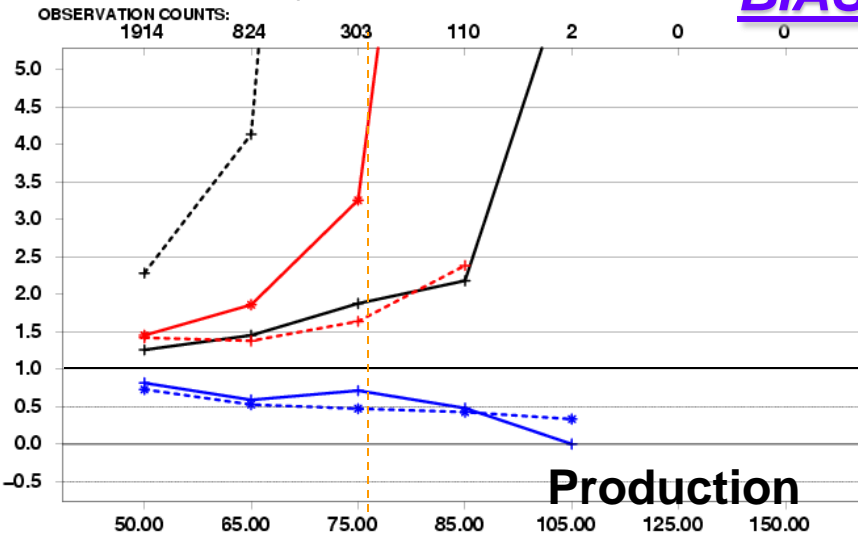


- Combination run (dashed red) similar to Prod run (black solid)
- Experimental run bias often largest

# NCEP Air Quality Research Forecast 2010 Verification

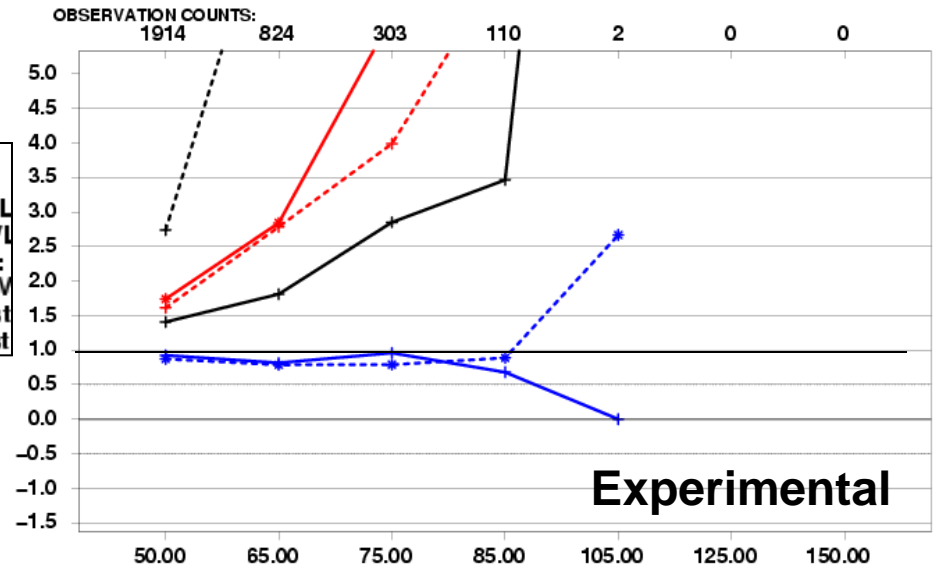
## Daily 8 hr Max ozone Errors for Day 2 (All Regions)

### BIAS by threshold



from 20100808 to 20100907 for 48 Hour Forecasts

—+—	CB04-production VARB: OZMX/8	RGN: Northeast LVL
- -+ -	CB04-production VARB: OZMX/8	RGN: Southeast LVL
—+—	CB04-production VARB: OZMX/8	RGN: Midwest LVL
- -+ -	CB04-production VARB: OZMX/8	RGN: LMiss-Vall LV
—+—	CB04-production VARB: OZMX/8	RGN: NWest-Coast
- -+ -	CB04-production VARB: OZMX/8	RGN: SWEST-Coast



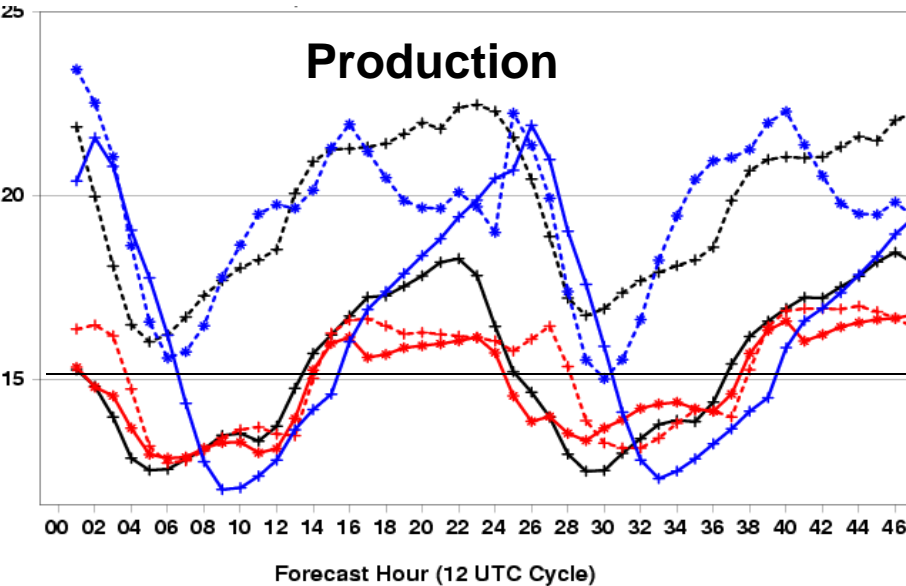
- Combo run similar to Prod run  
Except worse over Midwest

# NCEP Air Quality Research Forecast 2010 Verification

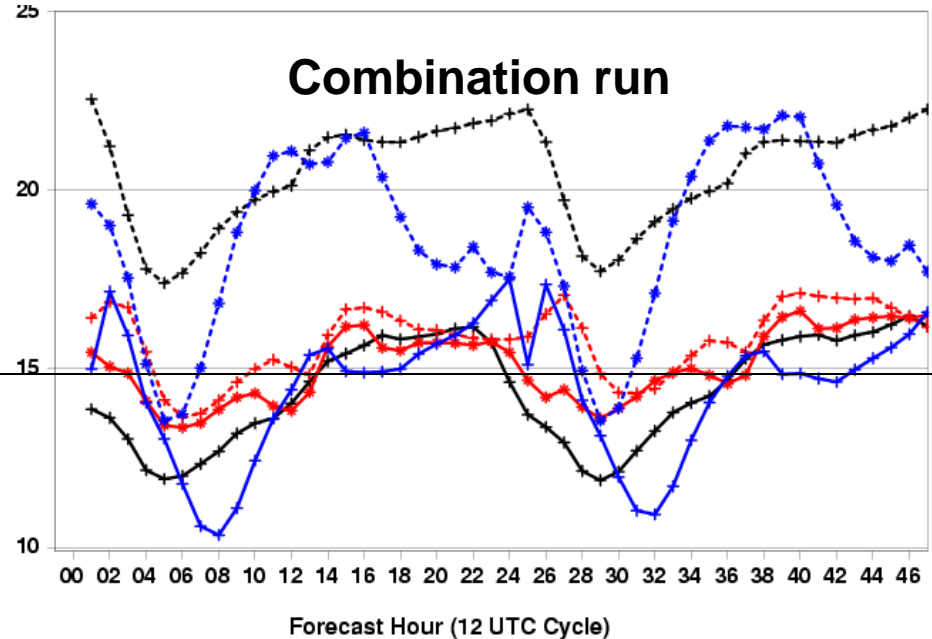
## Daily 8 hr Max ozone Errors for Day 2 (All Regions)

RMSE

**Production**



**Combination run**

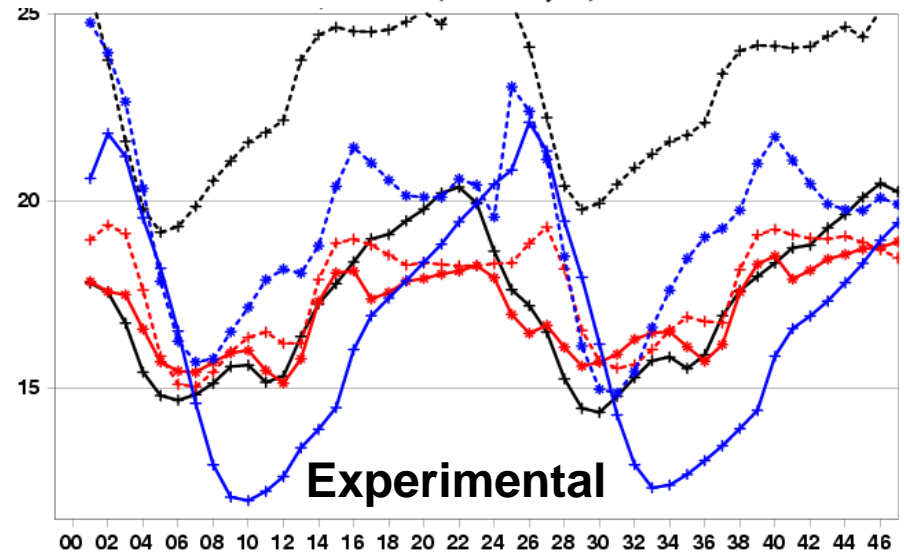


from 20100808 to 20100907 for 48 Hour Forecasts

—+—	CB04-production VARB: OZMX/8	RGN: Northeast LVL
- -+ -	CB04-production VARB: OZMX/8	RGN: Southeast LVL
—*—	CB04-production VARB: OZMX/8	RGN: Midwest LVL
- -* -	CB04-production VARB: OZMX/8	RGN: LMiss-Vall LV
—+—	CB04-production VARB: OZMX/8	RGN: NWest-Coast
- -+ -	CB04-production VARB: OZMX/8	RGN: SWEST-Coast

Forecast Hour (12 UTC Cycle)

**Experimental**

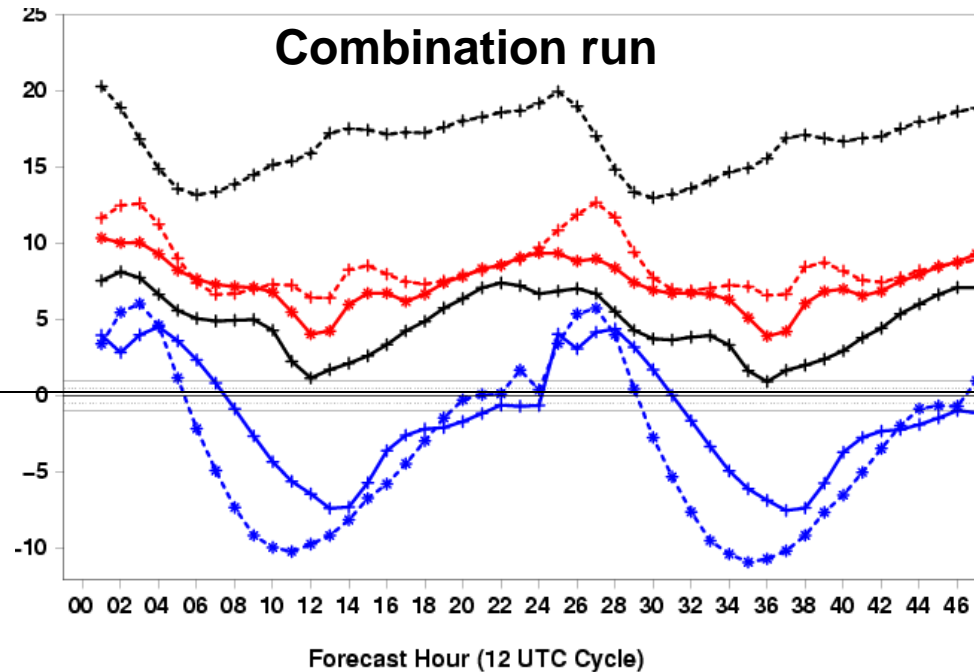
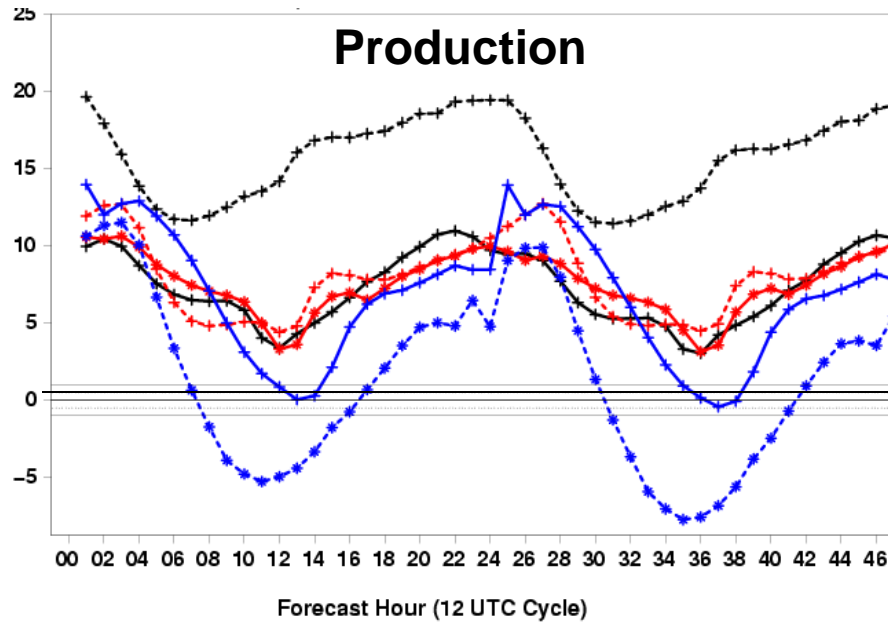


- Combo: NEC, NWC, SWC
- Prod: SEC, MDW, LMV

# NCEP Air Quality Research Forecast 2010 Verification

## Daily 8 hr Max ozone Errors for Day 2 (All Regions)

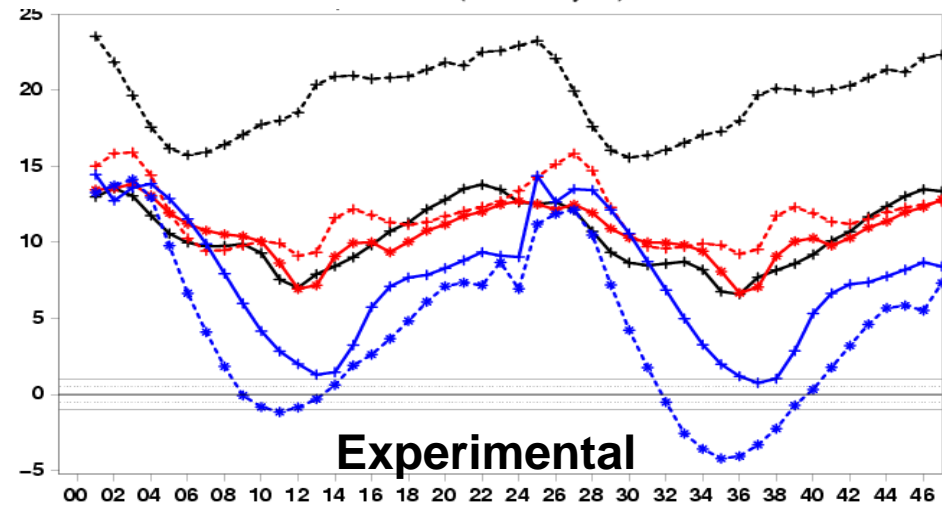
### BIAS



from 20100808 to 20100907 for 48 Hour Forecasts

—+—	CB04-production VARB: OZMX/8	RGN: Northeast LVL
- -+ -	CB04-production VARB: OZMX/8	RGN: Southeast LVL
—*—	CB04-production VARB: OZMX/8	RGN: Midwest LVL
- -* -	CB04-production VARB: OZMX/8	RGN: LMiss-Vall LV
—+—	CB04-production VARB: OZMX/8	RGN: NWest-Coast
- -+ -	CB04-production VARB: OZMX/8	RGN: SWEST-Coast

- Combo: NEC
- Prod: NWC, SWC
- Neutral: SEC, MDW, LMV

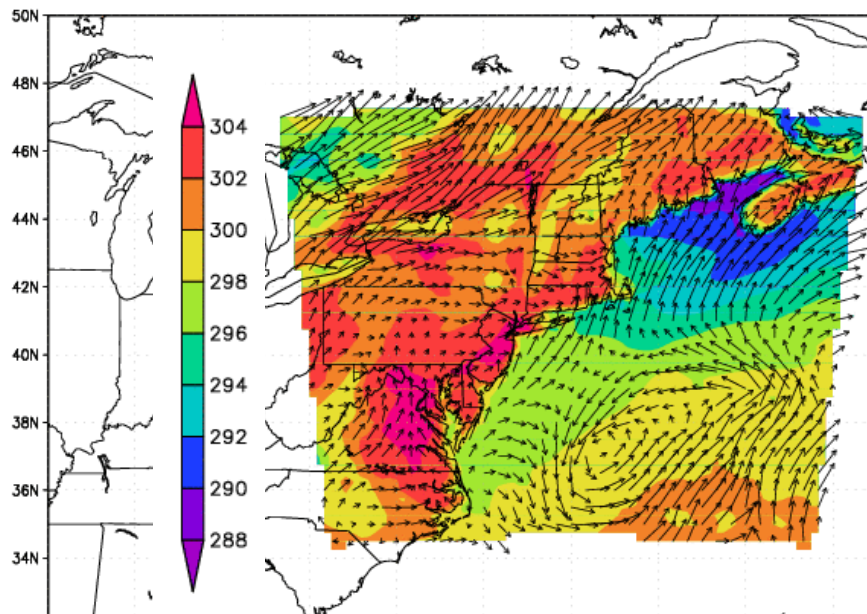


# Developmental Run Evaluation Summary

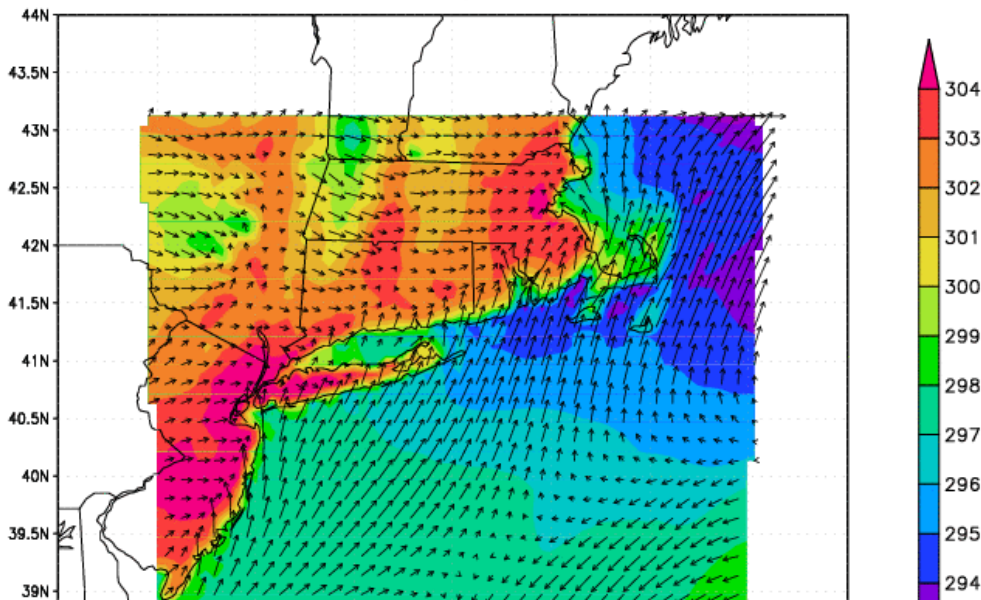
## (Best run performance by score)

Run	CONUS	EAST	WEST	NEC	SEC	MDW	LMV	SWC
Prod	8h max FC, DTS	8h max FC, 1h avg nite	1h Bias		8h max FC, 1h avg	8h max FC, 1h avg	8h max FC, 1h avg	1h avg bias
Neutral			8h max FHO	8h max FHO				8h max FHO
Comb	1h avg RMSE/ Bias	1h avg daytime RMSE/ Bias	1h avg RMSE	1h avg bias/ rmse				1h avg rmse

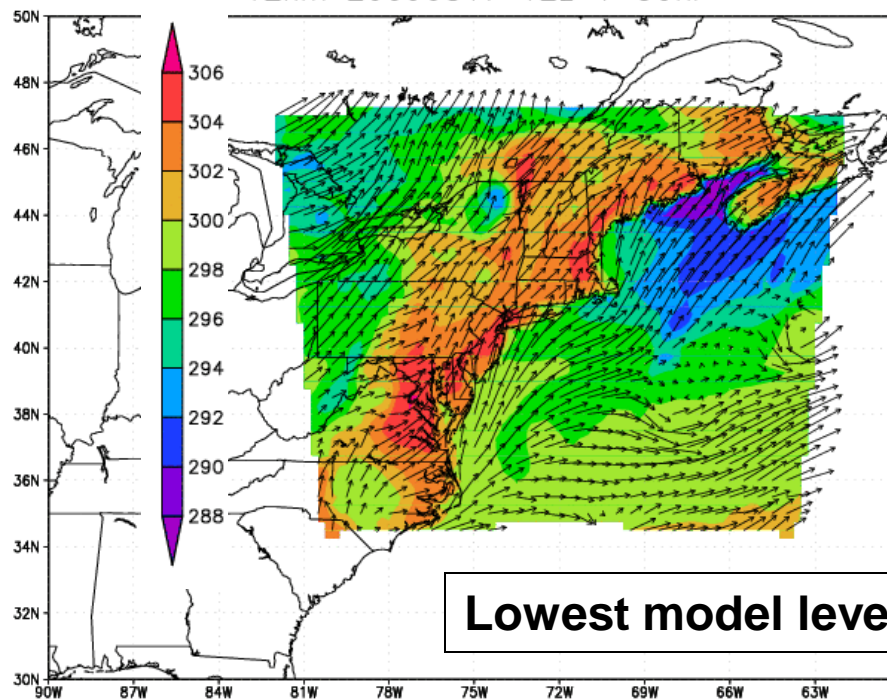
12km 20090817 12z + 06



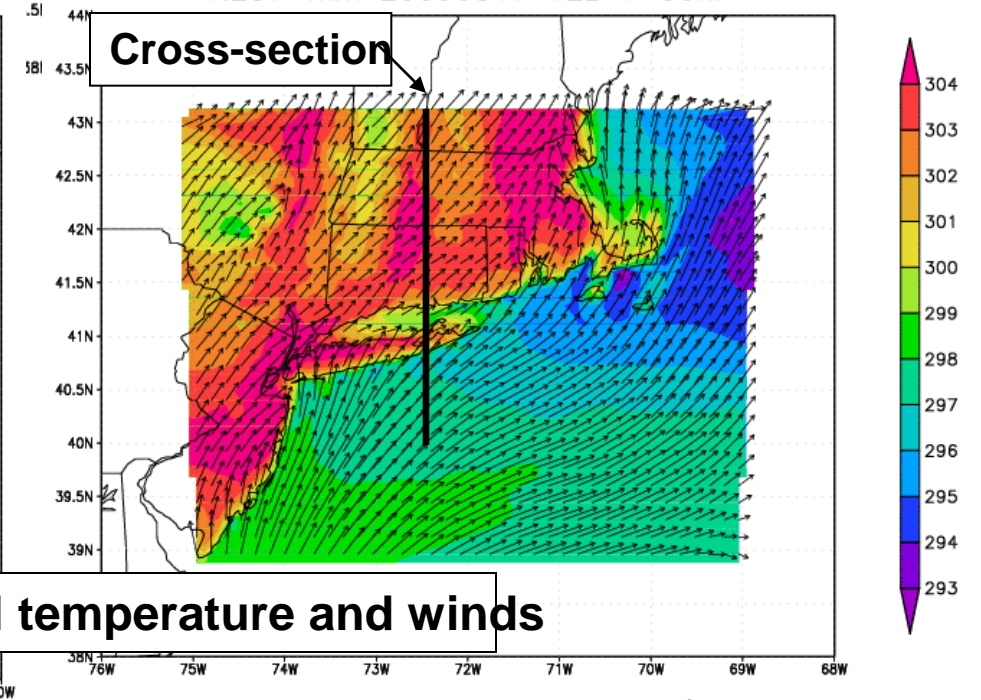
NEST 4km 20090817 12z + 06



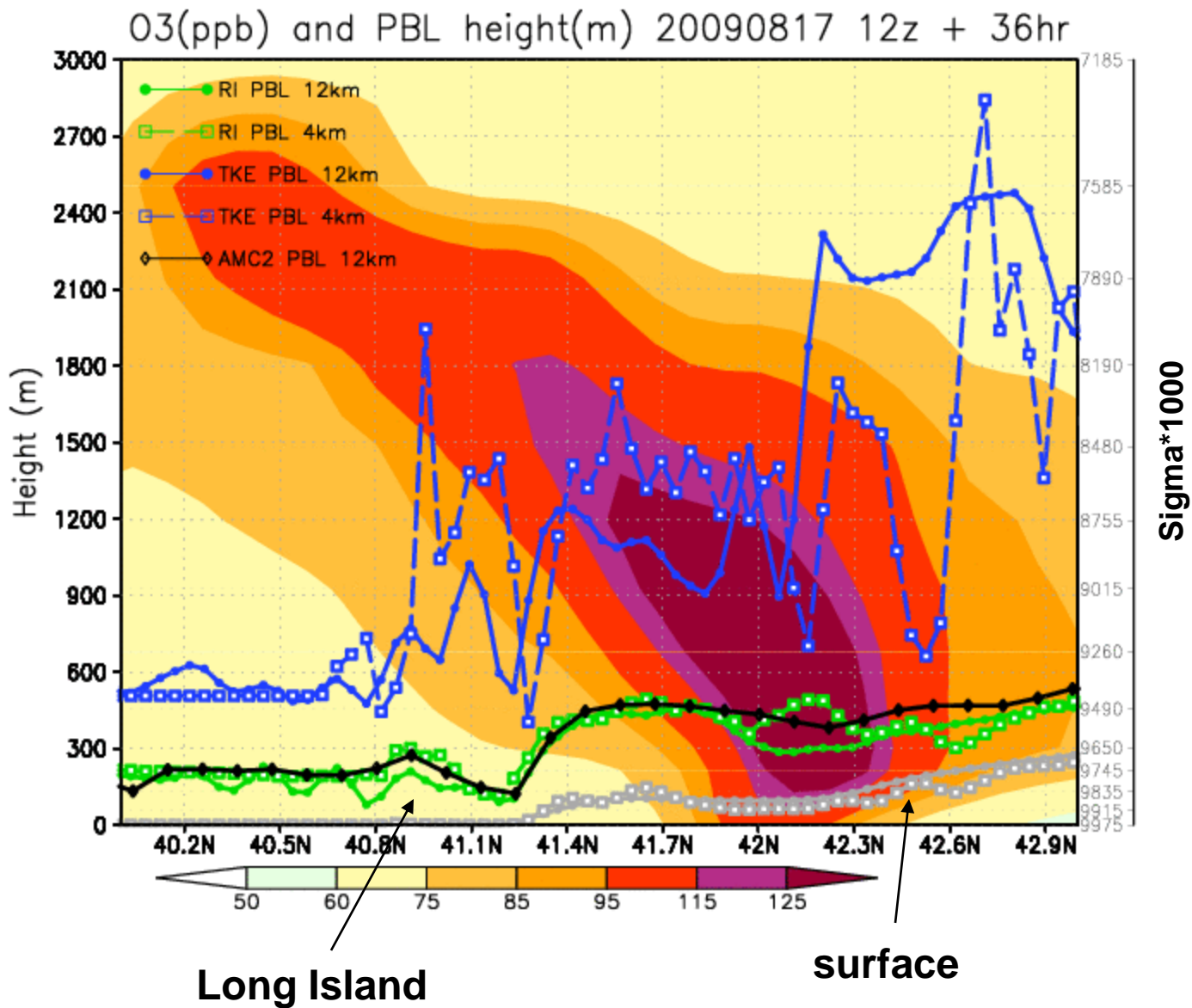
12km 20090817 12z + 30hr



NEST 4km 20090817 12z + 30hr



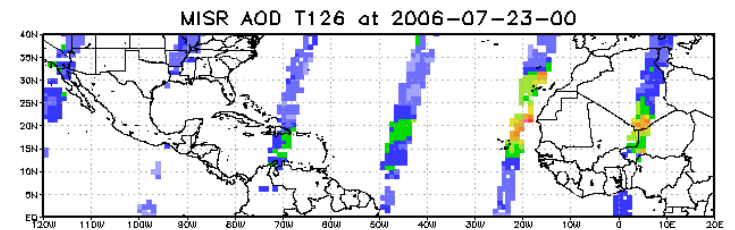
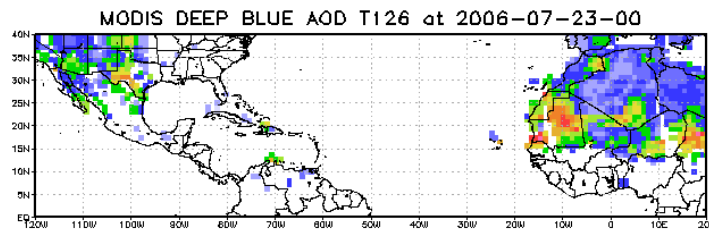
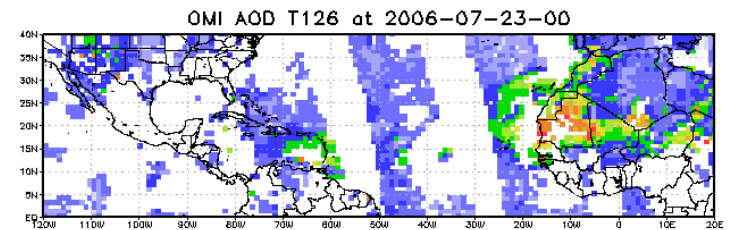
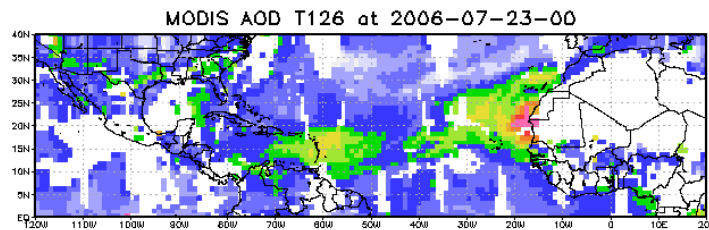
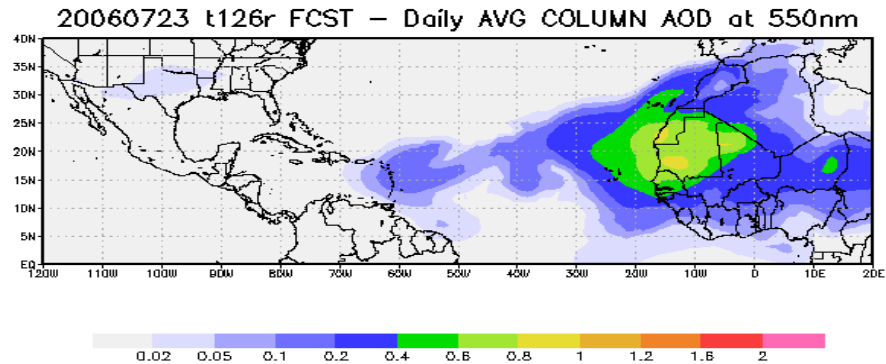
Lowest model level temperature and winds



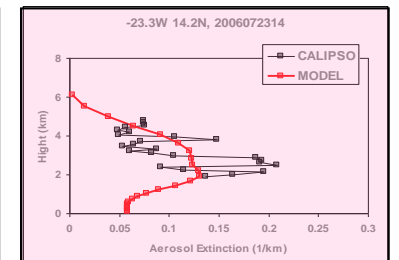
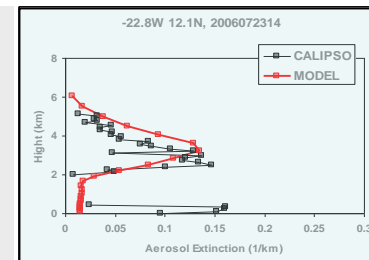
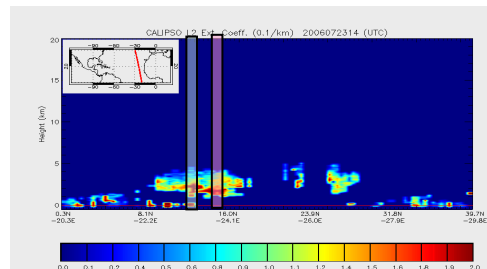
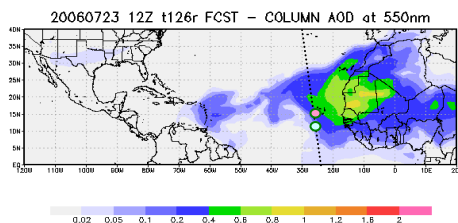
Ozone from production run and PBLs from different simulations 28

## Evaluation using column AOD:

MODIS, OMI, MISR,  
DEEP BLUE, AERONET

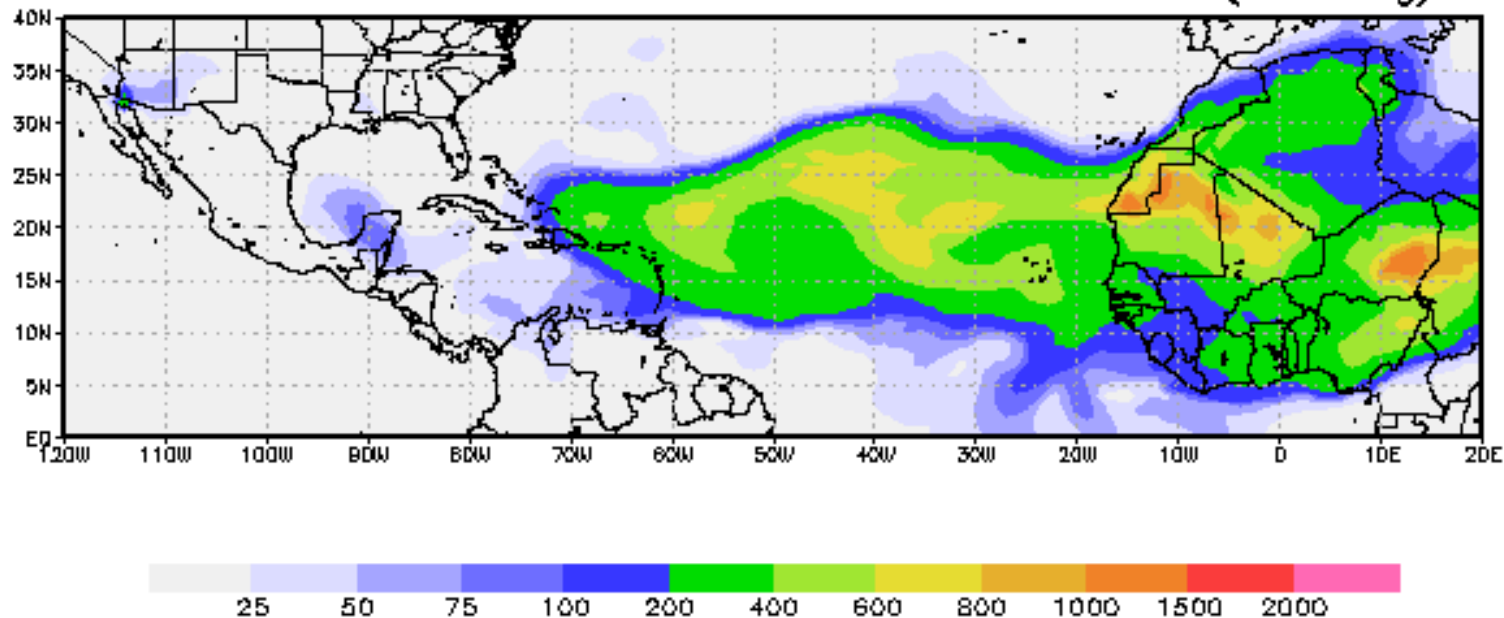


## Evaluation using vertical profile: CALIPSO



# Total dust mass loading of model column from July 15 – July 28 2010

20100715 00Z Fcst 1x1d Column total 0.1–10  $\mu\text{m}$  ( $10^{-3}$  g/m<sup>2</sup>)



GRADE For PM forecast, do not forget the source outside CONUS domain.

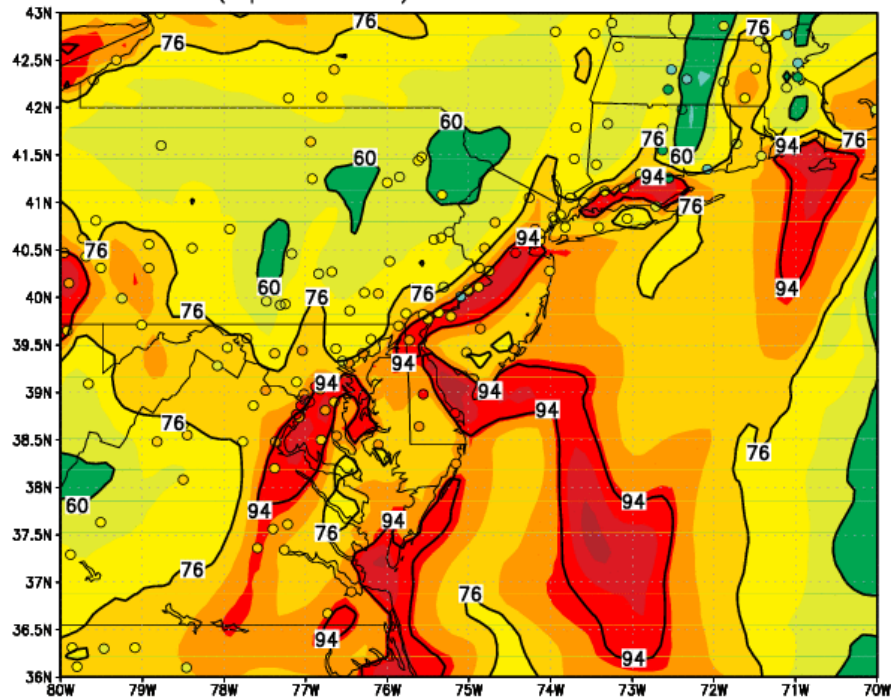
# BACKUPS

# NCEP NAM Verification

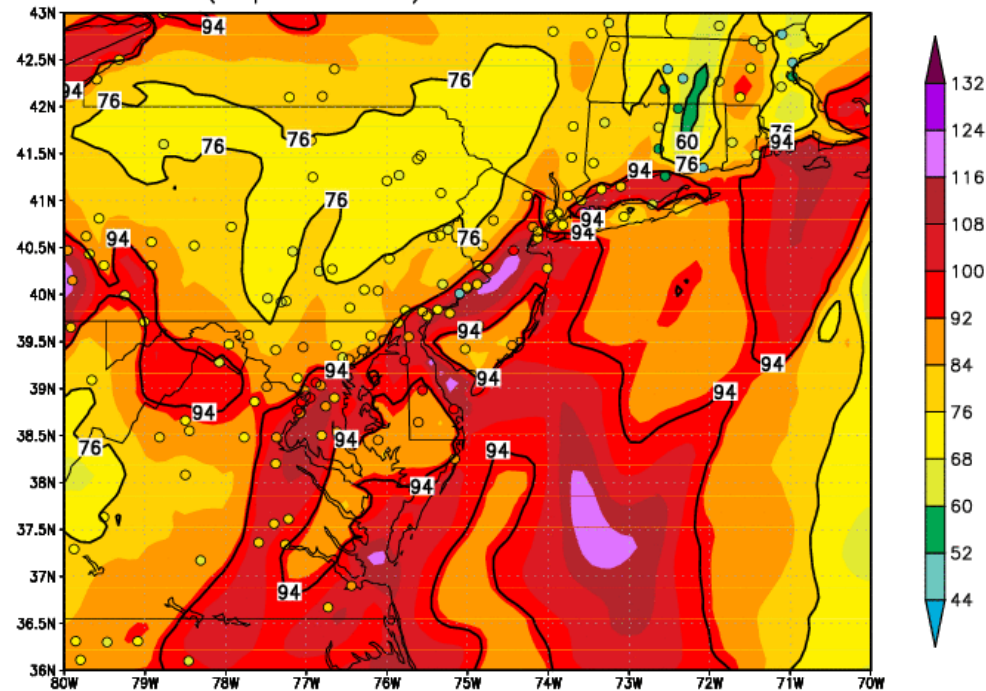
## 36 hour 2 m T Forecast valid 00 UTC

### July 7, 2010: NE U.S.

5x (Operational) 8-hr max 07JUL2010



5x (Experimental) 8-hr max 07JUL2010

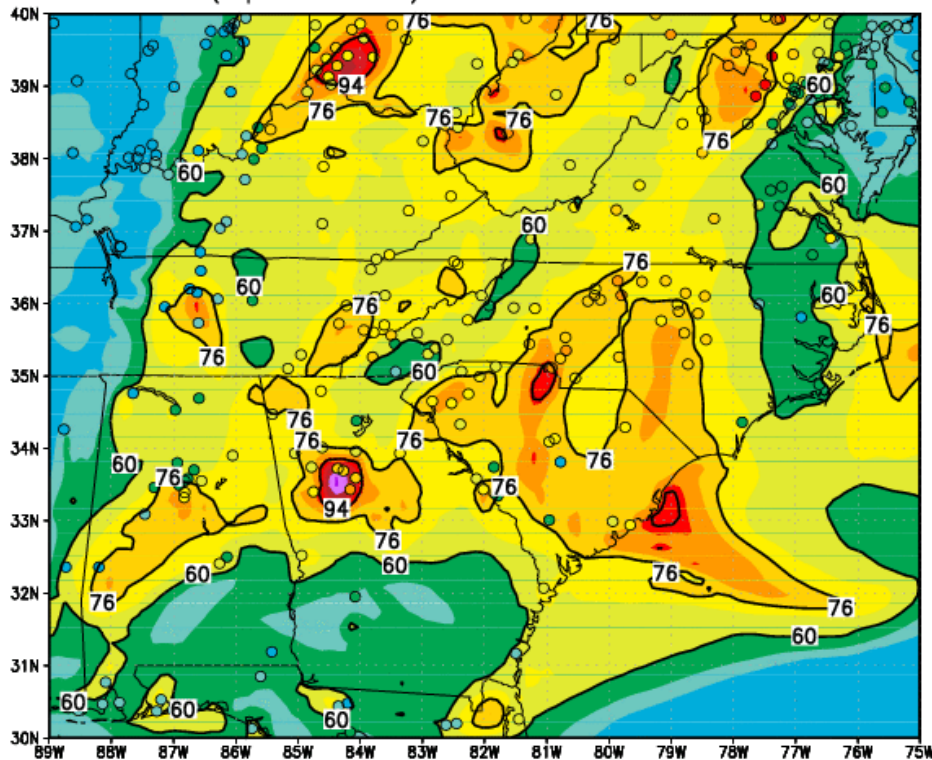


# NCEP Air Quality Forecast

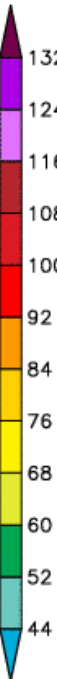
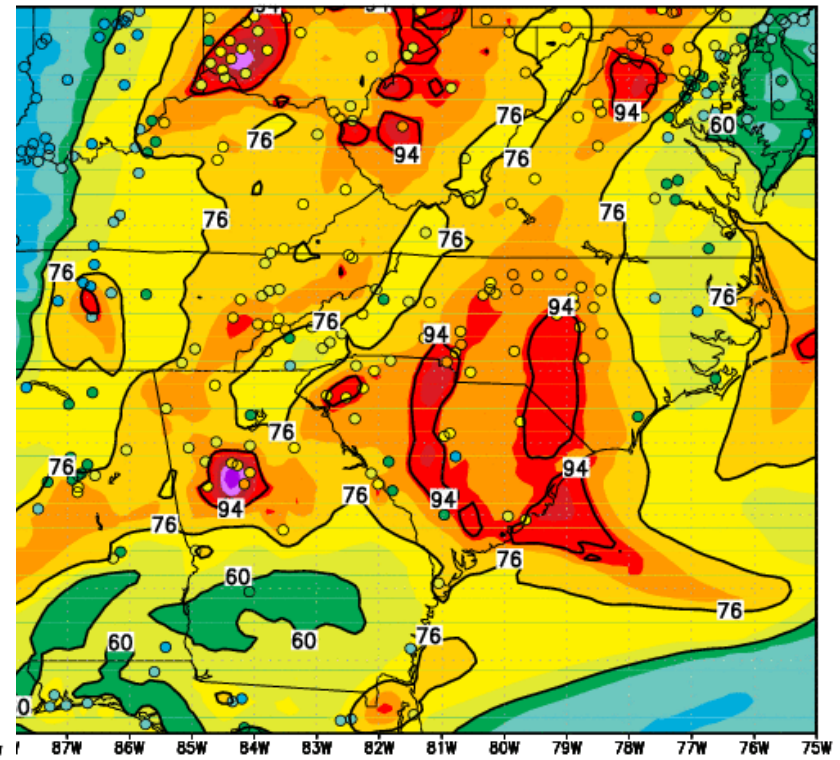
## 8 hr Day 2 Daily Max ozone

### July 8, 2010 SE U.S.

5x (Operational) 8-hr max 08JUL2010



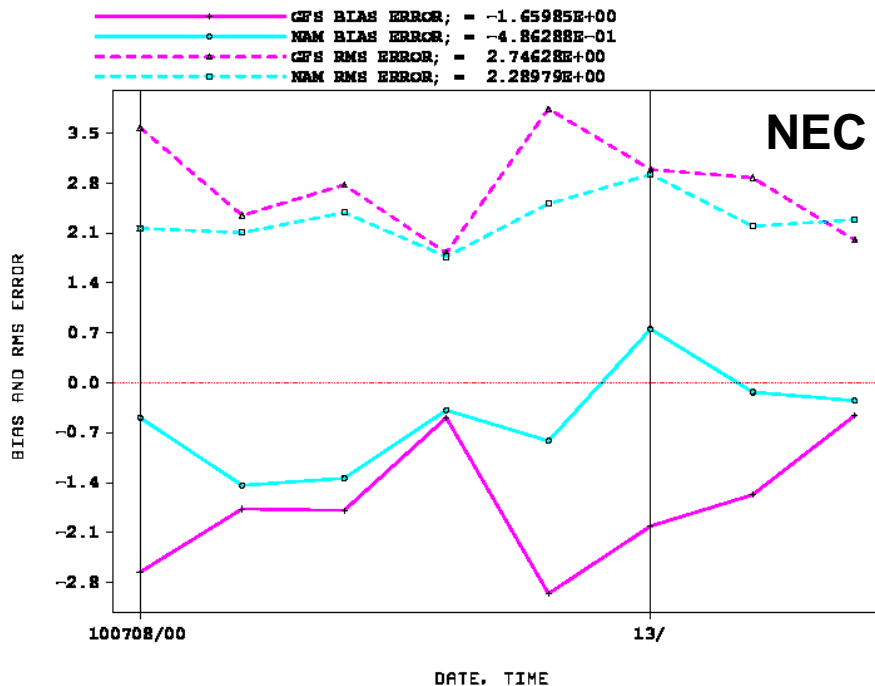
5x (Experimental) 8-hr max 08JUL2010



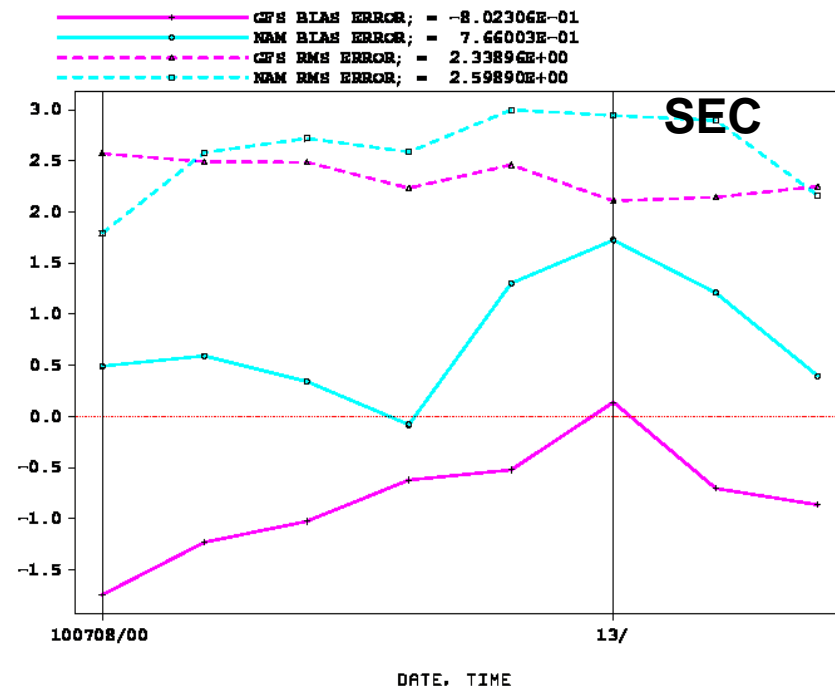
# NCEP NAM forecast

## 36 hour 2 m Temperature RMSE & BIAS valid 00 UTC July 8-July 15, 2010

STAT-SL112 PARAM-T FPDUR-36 V\_ANT-ONLYSF V\_RGN-G104/NEC LEVEL-SFC VHHMM-0000



T-SL112 PARAM-T FPDUR-36 V\_ANT-ONLYSF V\_RGN-G104/SEC LEVEL-SFC VHHMM-0000



NEC: July 7-9 : Cold bias from -0.7 → -1.4 C  
SEC: July 7-9: Warm bias ~ +0.5

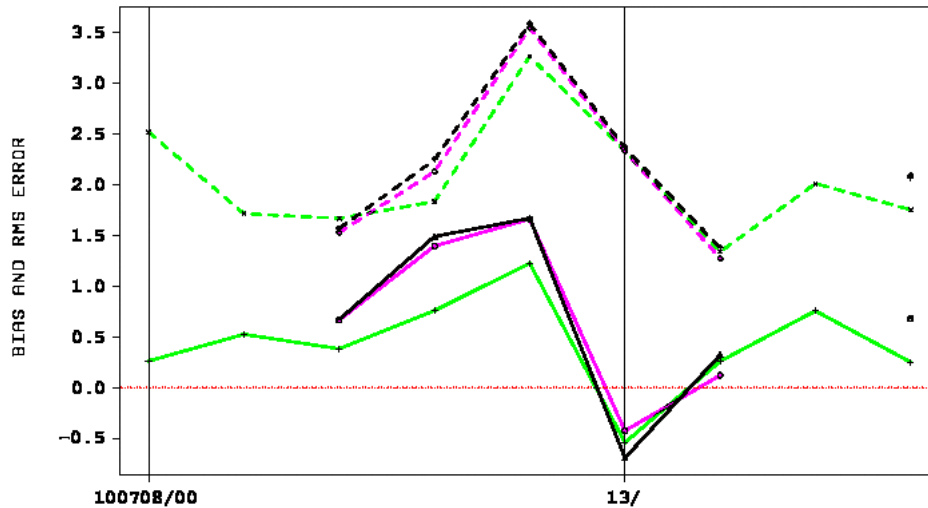
# NCEP NAM forecast

## 36 hour 2 m Dew point T RMSE & BIAS valid 00 UTC July 8-July 15, 2010

STAT-SL1L2 PARAM-DPT FHOUB-36 V\_ANT-ONLYSF V\_RGN-G104/NEC LEVEL-SFC VHEMM-0000

NAM BIAS ERROR; = 4.26558E-01  
NAMX BIAS ERROR; = 6.51544E-01  
NAMB BIAS ERROR; = 6.64731E-01  
NAMEXP BIAS ERROR; = MISSING  
NAM RMS ERROR; = 2.01657E+00  
NAMX RMS ERROR; = 2.09936E+00  
NAMB RMS ERROR; = 2.15633E+00  
NAMEXP RMS ERROR; = MISSING

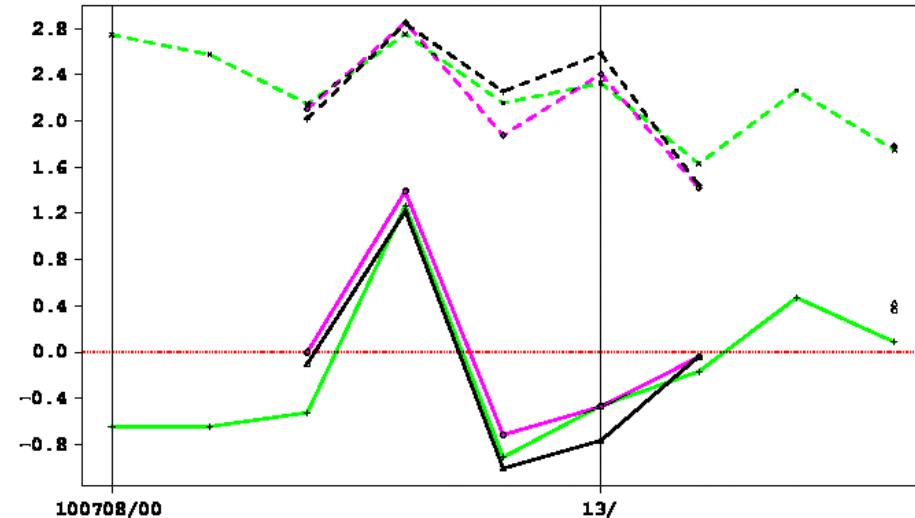
NEC



STAT-SL1L2 PARAM-DPT FHOUB-36 V\_ANT-ONLYSF V\_RGN-G104/SEC LEVEL-SFC VHEMM-0000

NAM BIAS ERROR; = -1.80677E-01  
NAMX BIAS ERROR; = 6.45245E-02  
NAMB BIAS ERROR; = -7.03880E-02  
NAMEXP BIAS ERROR; = MISSING  
NAM RMS ERROR; = 2.25489E+00  
NAMX RMS ERROR; = 2.07508E+00  
NAMB RMS ERROR; = 2.15782E+00  
NAMEXP RMS ERROR; = MISSING

SEC



NEC: July 7-9 : cold, moist bias

SEC: July 7-9: warm, dry bias → can contribute to O3 overprediction

# NCEP Air Quality Research Forecast 2010 Verification (Daily 8 hr Max ozone Western U.S. Errors for Day 2)

BIAS

RMSE

Para/Ctl

Prod

from 20100808 to 20100829 for 48 Hour Forecasts

—————+—————	CB04—production VARB: OZMX/8 RGN: CMAQ—CONUS
-----□-----	CB05—experimental VARB: OZMX/8 RGN: CMAQ—CONUS
—————*—————	CB05—Control VARB: OZMX/8 RGN: CMAQ—CONUS LVL
-----+-----	AQMTEST2 VARB: OZMX/8 RGN: CMAQ—CONUS LVL: 9

- Combination run improved compared to experimental/Para & Control CB05
- Similar behavior to prod run

# NCEP Air Quality Research Forecast 2010 Verification (Daily 8 hr Max ozone Eastern U.S. Errors for Day 2)

BIAS

RMSE

Para/Ctl

Prod

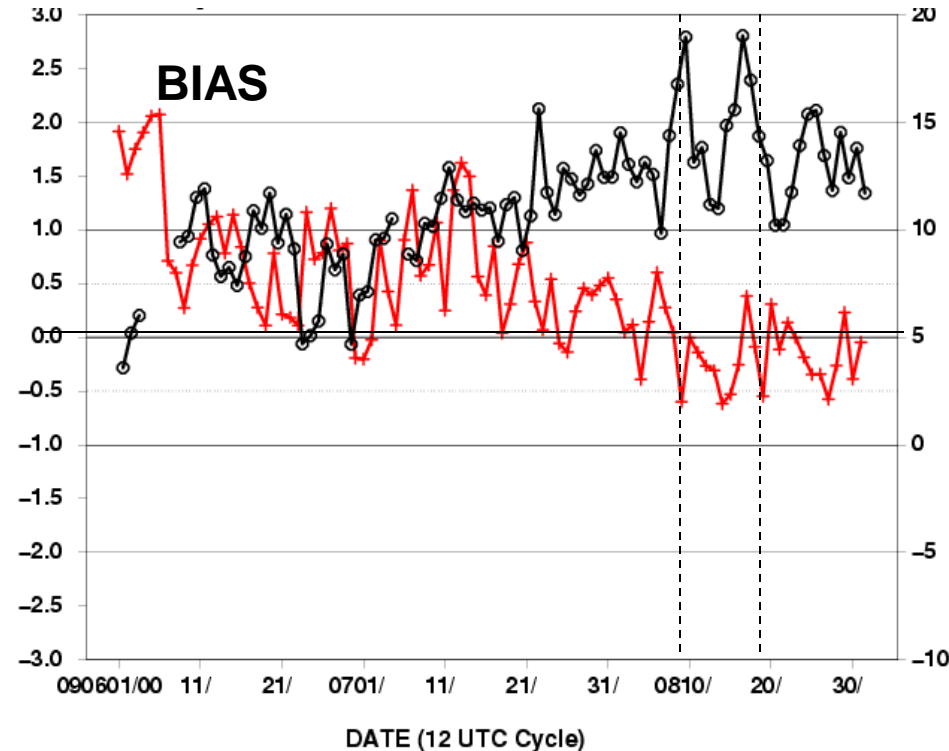
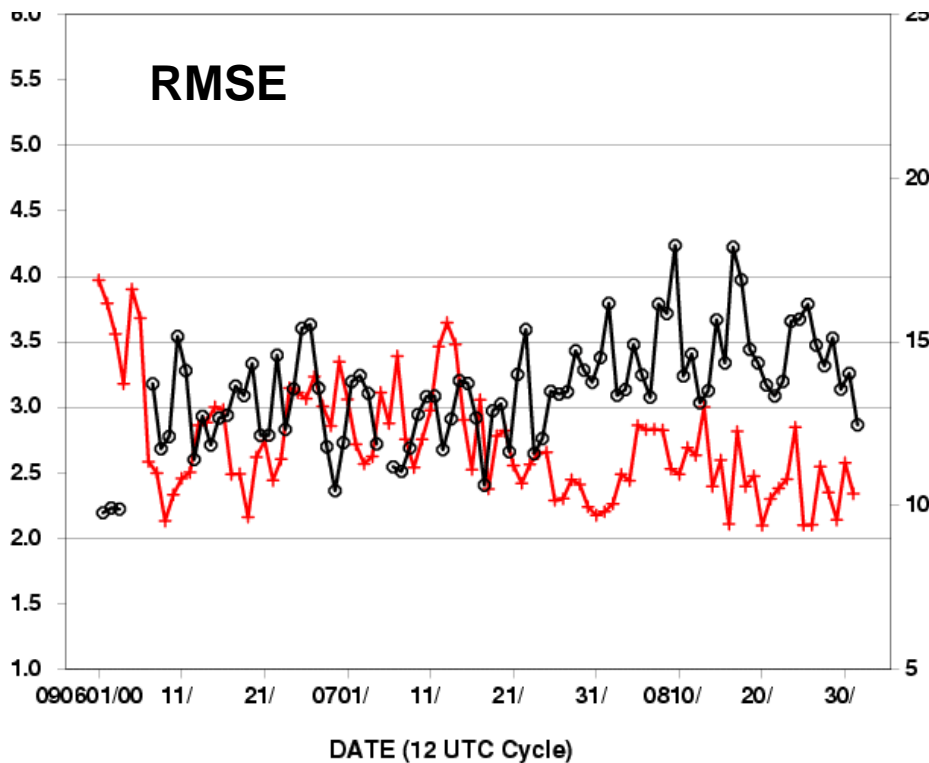
from 20100808 to 20100829 for 48 Hour Forecasts

—————+—————	CB04—production VARB: OZMX/8 RGN: CMAQ—CONUS
-----□-----	CB05—experimental VARB: OZMX/8 RGN: CMAQ—CONUS
—————*—————	CB05—Control VARB: OZMX/8 RGN: CMAQ—CONUS LVL
-----+-----	AQMTEST2 VARB: OZMX/8 RGN: CMAQ—CONUS LVL: 9

- Combination run improved compared to experimental/Para & Control CB05
- Similar behavior to prod run

# NCEP Air Quality Forecast 2009 Verification (1 hr Max ozone vs 36 h DPT error at 00 UTC) Eastern U.S. Experimental Run

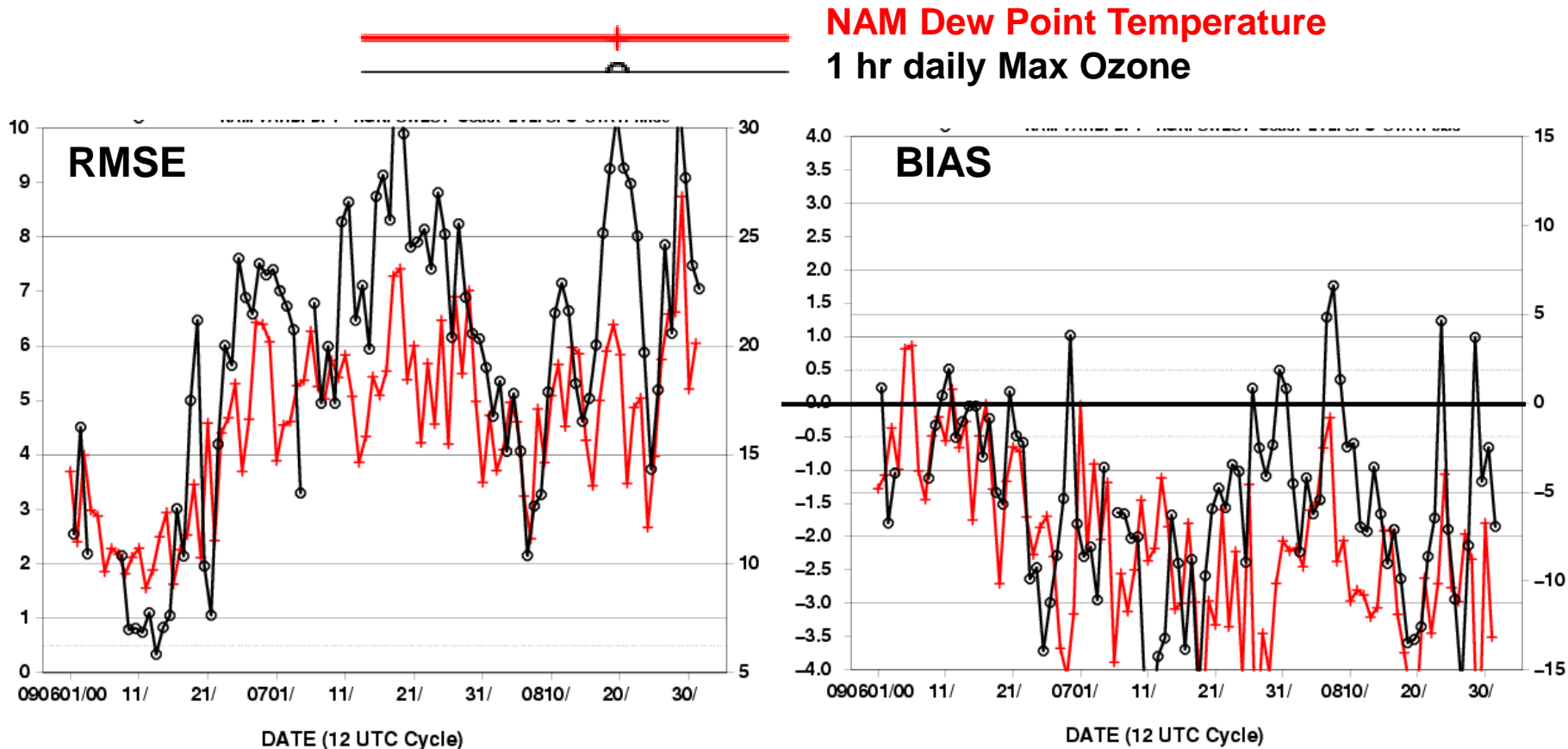
 **NAM Dew Point Temperature**  
**1 hr daily Max Ozone**



Increasing ozone errors as NAM moist errors are improved for the Eastern U.S.

- Shortwave, cloud cover contributing to ozone error
- cloud cover computed in CMAQ

# NCEP Air Quality Forecast 2009 Verification (1 hr Max ozone vs 36 h DPT error at 00 UTC) South West Coast Experimental Run



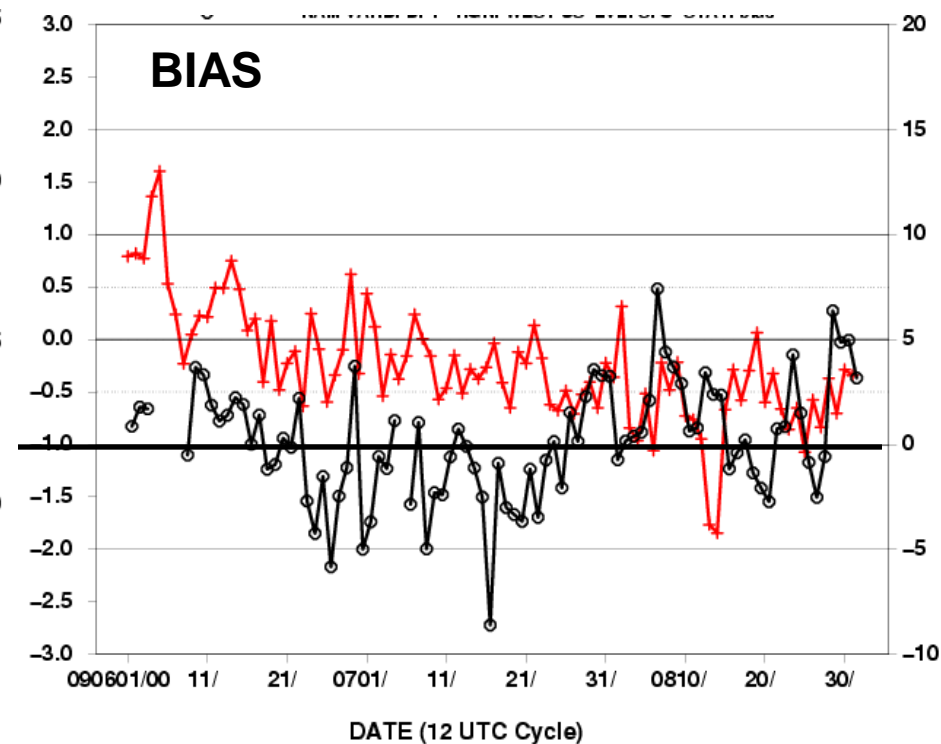
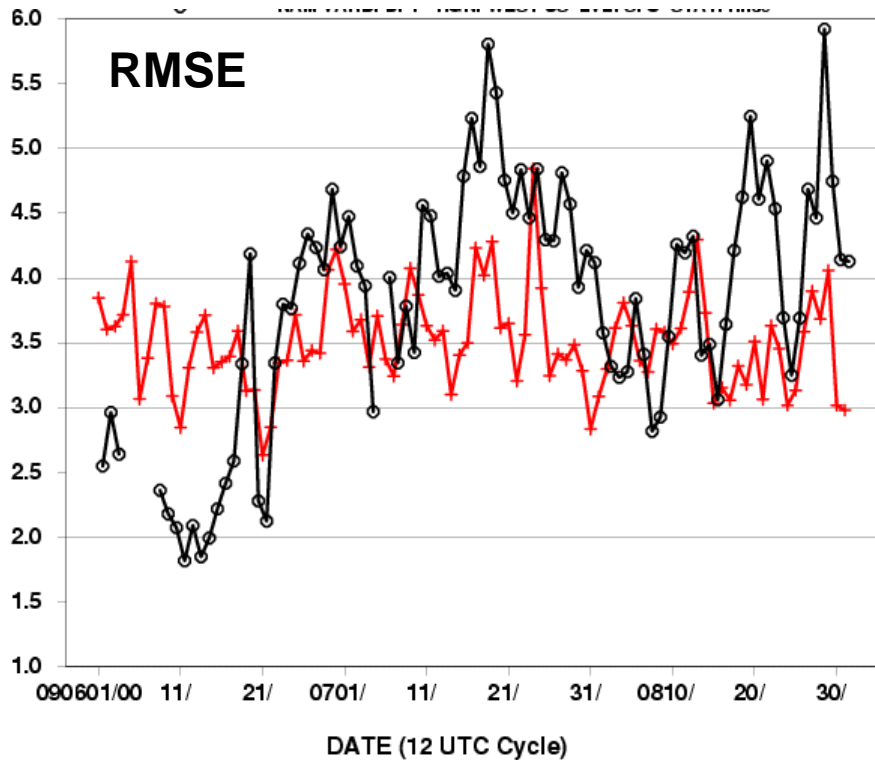
**CMAQ RMSE correlated to DPT RMSE**

**NAM too dry during high ozone events**

- Clear skies → over-estimates of short wave radiation

# NCEP Air Quality Forecast 2009 Verification (1 hr Max ozone vs 36 h DPT error at 00 UTC) Western U.S. Experimental Run

 **NAM Dew Point Temperature**  
**1 hr daily Max Ozone**



**CMAQ RMSE correlated to DPT RMSE**

**NAM too dry during high ozone events**

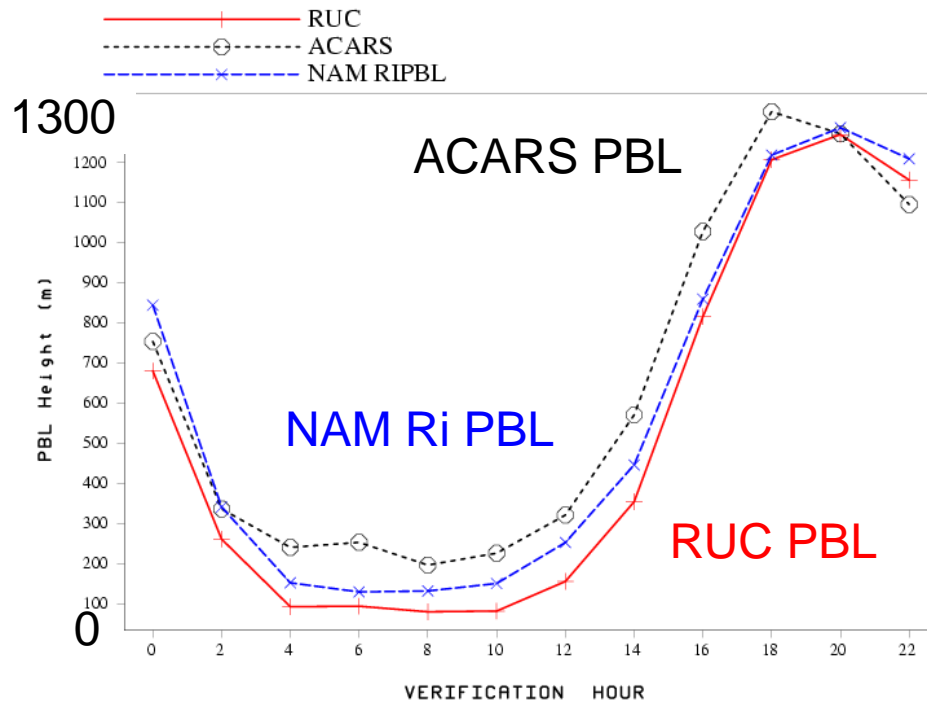
- Clear skies → over-estimates of short wave radiation ?

# *Model PBL verification*

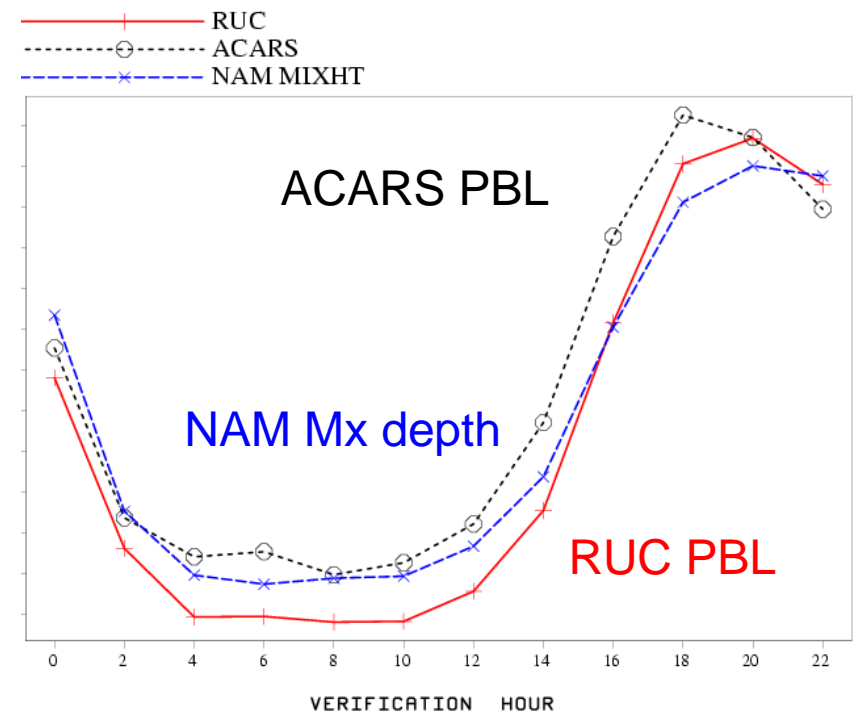
## *Diurnal evolution now can be evaluated*

CONUS domain: 10 – 27 June 2009

PBL Height (All forecast hours) 10 Jun to 27 Jun 2009–CONUS



ht (All forecast hours) 10 Jun to 27 Jun 2009–CONUS



NAM Ri PBL – low at night; relatively good in daytime  
NAM Mixed Layer depth – good at night; lower in daytime  
RUC – very low at night; similar to NAM Ri in daytime

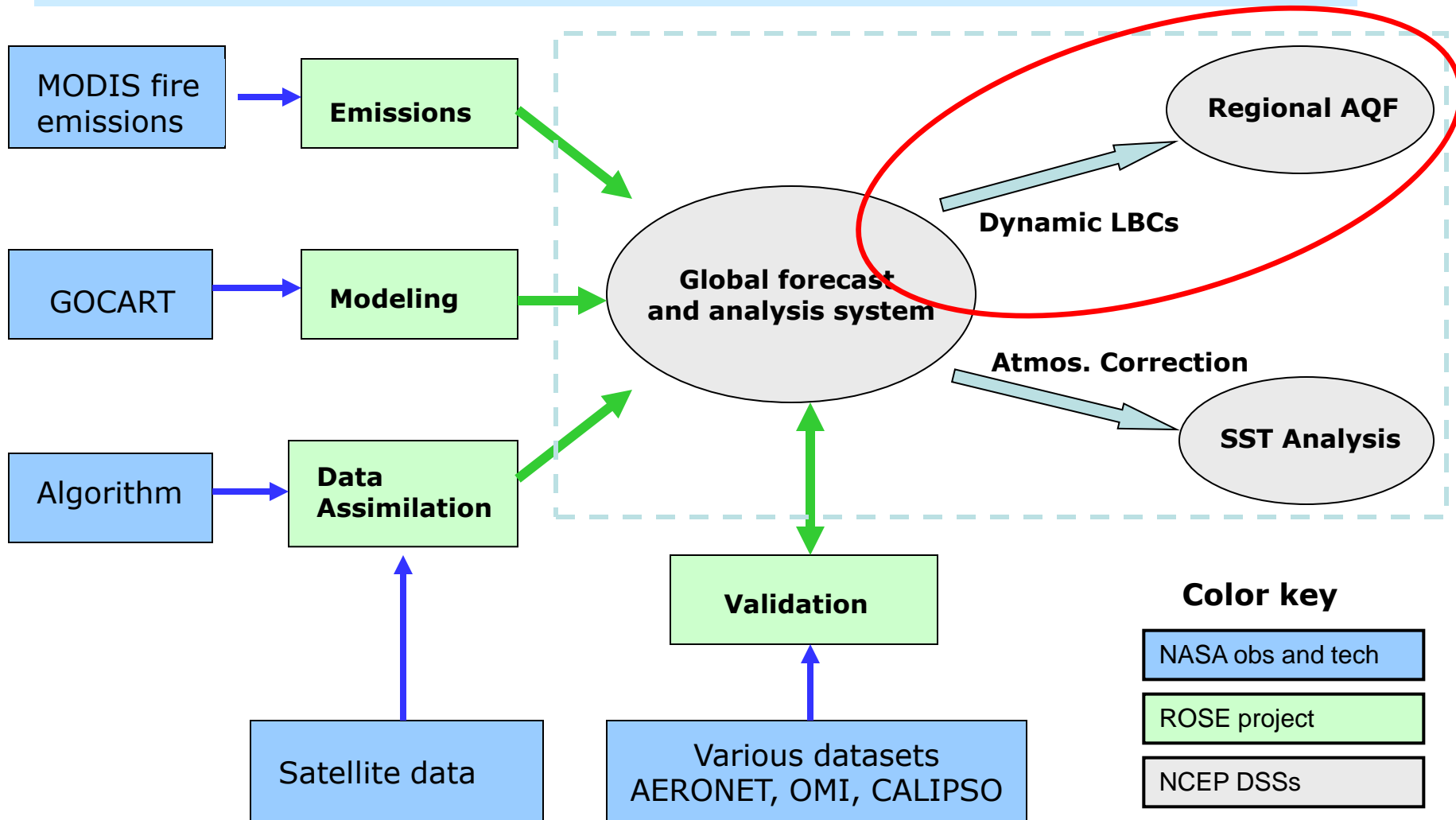
# Current Testing

- **CMAQ *Alaska and Hawaii* domain experimental runs:** J. Ping
- **CMAQ anthropogenic + *biomass smoke emissions*:** Y. Tang, A. Stein
- **CMAQ 12/4 km coupled to NCEP NMMB met model:** M. Tsidulko, Y. Tang & ARL
- **CMAQ Lateral Boundary Condition Impact Study :** Y. Tang, H. Huang
  - GOCART Global model w/ full aerosols (dust, *biomass*) coupled to CMAQ
- **Real-time Global Dust Forecasts:**, H-C Huang, S. Lu
  - GFS-GOCART offline coupling developed (w/ SAS, RAS convection)
  - GFS T382-GOCART 1 real-time runs to 48 hours *w/ 2.5 and 1 degree surface cover*
- **NMMB In-Line testing:** Y. Tang, Z. Janjic, C. Perez
  - Passive tracer capabilities added to WRF-NMM & NEMS-NMMB
  - Improvements to NEMS-NMMB advection routines
  - *DREAM dust emissions in NMMB*
- **Chemical Data Assimilation & global aerosol interactions :** H-C Huang
  - GEOS-5 GOCART aerosol analyses coupled to GSI & GFS/CFS radiation
  - Inline NEMS *inline GOCART module*
  - *Adding AOD tracer to GSI*

# Global aerosol forecast and analysis system

Sarah lu, Ho-Chun Huang, Dongchul Kim, C. Perez, Z. Janjic

**Goal: Improving weather and air quality forecasts by incorporating prognostic aerosols in GFS/NMMB and assimilating global aerosol information in GSI via NCEP-NASA/GSFC-Howard University collaborations**



# NAM-CMAQ Coupling

Run	NAM	CMAQ-Ops (CONUS) & CMAQ-Exp/Dev (CONUS PM)
Domain	<i>Rotated Lat-Lon E grid</i>	<i>Interp to Lambert-Conf. C grid</i>
Vertical Coordinate	<i>NMM Hybrid (60L)</i>	<i>Common NMM Hybrid coord (22L)</i>
Radiation/ Photolysis	<i>Lacis-Hansen Bulk</i>	<i>NAM Surface clear-sky Radiation for Photolysis Scaling</i>
PBL	<i>Mellor-Yamada-Janjic (MYJ) local TKE</i>	<i>Asymmetric Convective Mixing -2 (1<sup>st</sup> Order closure for daytime PBL)</i>
Clouds Aqueous	<i>Ferrier cloud water, graupel/ice</i>	<i>NAM cloud water, graupel/ice</i>
Convective Cloud Mixing	<i>Betts-Miller-Janjic Mass Adjustment</i>	<i>Asymmetric Convective Model (ACM) mixing</i>
Land Surface * PM	<i>NOAH LSM</i>	<i>Canopy resistance from NOAH LSM</i>